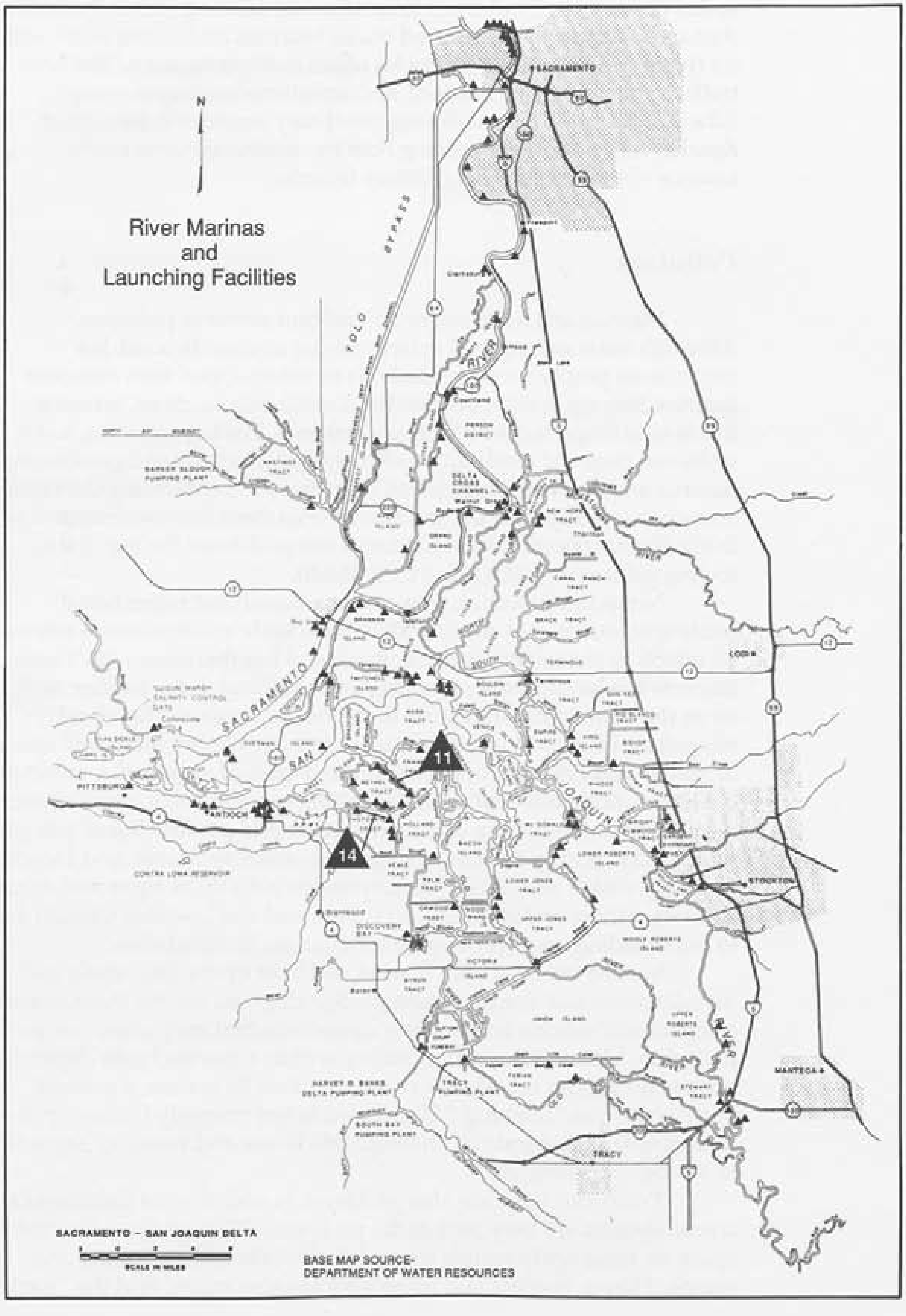
Figure 45. Location Map of River Marinas.



riverine environment. (SLC, 1986). Power boats must keep their speed down to five miles per hour to avoid causing wakes that could damage the marinas or moored boats. Marinas add to the boat traffic on rivers, which at times resembles urban traffic congestion. This boat traffic conflicts with the needs of, and sometimes endangers, people fishing. And lastly, marina development may require the removal of riparian vegetation and dredging both for construction and maintenance—both of which may destroy fisheries.

Pollution

Marinas and boats can be a significant source of pollution. Although boats are required to have proper sewage disposal, few marinas use proper handling methods or are equipped with pumpout facilities. Sewage is often disposed of directly into the rivers, an action that is now illegal but not effectively enforced. Fueling accidents, leaky tanks and lines and carelessness allow spilled oil, diesel and gasoline into marinas and the rivers themselves. Paint and toxic antifouling chemicals contaminate many marinas, and spread from there into the rivers, often in significant concentrations. California has prohibited the use of antifouling paint since 1988 (Title 3 CCR §6488).

Nonpoint pollution from marina-based and recreational boating activities may also result in detectable adverse environmental effects to the nearby water column and benthic resources. These impacts can be caused by physical and chemical disturbances: toxicity in the water column related to decreased levels of dissolved oxygen and elevated levels of metals and petroleum; increased levels of metals and organic chemicals in the tissues of organisms; levels of pathogen indicators that result in fishing or swimming area closure; disruption of the bottom during dredging and positioning of pilings which may destroy habitat, resuspend bottom sediment, and increase turbidity which affects the photosynthetic activity of algae and estuarine vegetation; and shoaling, shoreline and shallow area erosion due to bulkheading, motorboat wake or changes in circulation.

Marina construction; marina and boat operation, repair and maintenance; and dredging and dredge disposal are the three source categories of marina and boating operations that may cause nonpoint pollution. Maintaining water quality within a marina basin depends primarily on how readily the marina renews its waters, a process aptly known as "flushing." If a marina is not properly flushed, pollutants will concentrate to unacceptable levels and result in impacts to biological resources.

Trash and litter are also problems in and around California's rivers. Boaters are only part of the problem, although the restricted space on most boats tempts many into "overboarding" paper and plastic. Hikers, anglers and picnickers are also guilty, and the "pack it in, pack it out" ethic is still a long way from universally being adopted. Trash collection facilities are often long distances apart and, in eras of tight budgets, are often not emptied frequently enough.

Riverside Development

Riverside development for commercial or residential use detracts from all forms of recreation. This development may restrict public access to the river, notwithstanding Article IV, and the Subdivision Map Act (see Chapter 5). Boaters' recreational experience may be more memorable for the urbanscape view that has replaced the riparian forest.

Today, even with at least 80-90 percent of riparian habitat in most Western states eliminated (Faber and Holland, 1988), the remaining pieces are still being threatened by development. While cutting for fuelwood is now minimal, and agricultural clearing is probably no longer occurring to a great extent, urbanization poses a serious threat. Riversides are desirable places to site a home or business, and development along rivers and in the flood plain also brings with it the need for flood control, which results in more vegetation removal.

California Rivers: Regional Perspectives

3

Each ecosystem has intrinsic value. Just as a country treasures its finite historical episodes, classic books, works of art, and other measures of national greatness, it should learn to treasure its unique and finite ecosystems, resonant to a sense of time and place. E.O. Wilson. *The Diversity of Life*, 1992.

Introduction

Within California's borders are lands and waters which encompass an enormous variety of environments—including a broad range of climates, soils, topography and oceanographic features. In this chapter, the incredible natural diversity within California—from the desert Mojave and Amargosa rivers, almost entirely dry, to the constantly cold, spring-fed Pit and McCloud Rivers above Shasta Dam—is explored regionally to illustrate the continuity and public trust-related elements of rivers. California's climate, and her rivers' complex geologic and biological histories, are exceptional in natural diversity.

In order to ensure the permanent sustainability and productivity of terrestrial, aquatic and wetland resources, California's natural diversity, especially our biological diversity, must be protected. The "bioregional" and "watershed council" movement in grass roots organizations and in government indicates a growing realization that a regional approach in protecting and enhancing California's natural resources is the most rational course to take. (See Andruss et al., 1990, and California's Coordinated Regional Strategy to Conserve Biological Diversity, 1991.)

Rivers integrate living resources (biotic) and the non-living (abiotic) environment over an entire watershed. A single drainage basin can cover large regions, as in the case of the Sacramento/San Joaquin River drainage which encompasses one-third of the state's land area. It is especially appropriate that river management, including ecosystem restoration, is done using a regional approach, which recognizes both the interrelationships between watershed and river and the significant differences between different ecoregions (National Research Council, 1992).

For the primarily descriptive purposes of this report, the state has been divided into seven river regions (Figure 46), based on a combination of geomorphic or physiographic province (Jenkins, 1938), major hydrologic basin or drainage unit, distribution of fish (Moyle, 1976) and composition of riparian woodlands (Roberts et al., 1977). There are about 7,800 miles of rivers in California (SLC GIS analysis based on 1:1,000,000 USGS Hydrography map). The distribution of rivers and size of each region discussed in this report are summarized in Table 4.

Each region is characterized and a "case study" is provided for the public trust resource issues: wildlife habitat, water pollution affecting aquatic resources, public access, recreation, and watershed management for restoration and sustainability. Table 13 is a list of common riparian plants of California, followed by Table 14—common animals of California. These lists are found at the end of this chapter.

Table 4. Distribution of Major Rivers by Region.

Region	Length of Major Rivers		
	Miles	Rel.%	Acreage (mill.)
North Coast/Klamath	1381	18	13.5
Central Valley	3863	49	33.5
Modoc/Cascade	399	5	4.5
Central Coast	611	8	9.1
Eastside/Great Basin	369	5	6.6
South Coast	571	7	6.9
Desert	606	8	27.2
TOTAL	7800	100	101.3

Kreissman, 1991.

Figure 46. River Regions of California.

Figure 47. North Coast/ Klamath Region.

North Coast/Klamath Region

The North Coast/Klamath region is typified by some of the most rugged mountains in the state, heavily forested with coniferous trees. Most of this land is wild and sparsely populated. The entire region has fewer people than the City of San Jose. The economy is dependent on enterprises associated with its natural resources: timber production, fishing, recreation and ranching. With its high rainfall, the region contains many large rivers—the Smith, Klamath, Trinity and Eel—and includes most of California's Wild and Scenic River segments. This entire region extends from the San Francisco Bay northward to the Oregon border and encompasses the North Coast and the north San Francisco Bay hydrologic basins.

Some find the setting, especially along the Sonoma and Mendocino coasts, suggestive of the Scottish Highlands with its sheep and its windswept bleakness. But it is the Redwood and Douglas-fir forests and seeming unending expanse of trees that make up most of this region. The North Coast/Klamath region is riddled with active faults and is undergoing rapid tectonic uplift. As a result, most rivers draining this region have high gradients, flow through steep-sided, confined gorges, and carry exceptionally large sediment loads. The area's geomorphology, and thus its river systems, varies between two subregions: the Coast Ranges in the south and the Klamath Mountains in the north.

The Coast Ranges subregion, from the Eel River southward, is underlain by easily eroded sedimentary rocks of the Franciscan Formation. The Eel River carries the highest average annual sediment load in the contiguous United States, over 15 times the yield of the Mississippi (Brown and Ritter, 1971), and its watershed is among the most erosive in the world (Beaumont, 1975). The longer rivers that drain the Coast Ranges—the Eel, Russian, Napa and Petaluma rivers—follow the northwest alignment of the mountains and faults.

The Klamath Mountains subregion is dominated by the large Klamath River system, with a drainage area of 12,000 square miles, This system includes several major tributaries—the Trinity, South Fork Trinity, Salmon, Scott and Shasta rivers. The Klamath has cut its gorge across the entire width of the Klamath Mountains.

The Klamath Mountains watersheds are generally less erodible than the Coast Ranges. For example, the Smith River near the Oregon border, now included within a National Recreation Area, drains a watershed of highly resistant rocks and is famous for the speed with which it clears after major storms. A notable muddy exception in the Klamath Mountains is a portion of the Trinity River watershed that contains decomposed granite soils, which are extremely vulnerable to erosion. Logging in the 1940s and 1950s resulted in extensive watershed damage, leading to severe sediment problems for salmonid habitats on the Trinity River (Bramhall, 1989).

Figure 48. Klamath River Gorge.

The North Coast/Klamath region overall has the highest rainfall in California, but its distribution is strongly controlled by location, especially relative to topography. San Rafael on San Francisco Bay and Fort Bragg on the coast both receive about 38 inches of rain annually. Areas in the steep King Mountain Range of the Mattole River drainage average more than double that, with 80-90 inches annually. In the unusual water year of 1982-1983, sites in the Mattole headwaters area just inland and north of Shelter Cove were drenched by an almost inconceivable 240 inches of rain.

Over the whole North Coast/Klamath region, precipitation (nearly all rain) is concentrated in the winter months. Runoff follows this seasonal pattern, with massive winter floods in response to intense rainfall, followed by a gradual decline in spring to summer base flow which can be no more than a trickle in late summer. This pattern is true even for large rivers on the North Coast. Also visible are the extremely rapid rises in river stage, such as the increase from 60,000 cubic feet per second (cfs) to 230,000 cfs in three days.

There are three general patterns of riparian vegetation found along the rivers of the region: 1) the Klamath Mountains; 2) the alluvial valleys of the Coast Range; and 3) the foggy coastal strip. In the Klamath Mountains, most rivers are confined for much of their lengths, and riparian vegetation zones are typically narrow. The high winter rainfall and resultant high flood peaks subject riparian zones to frequent scouring, erosion and deposition.

Along the low-gradient flood plain reaches of big rivers, the riparian habitat is more extensive, approaching in appearance the great river forests of the Central Valley. Large cottonwoods are often present along North Coast valley rivers.

Near the immediate coast, the distinction between riparian and upland vegetation is often blurred on the small rivers of the area, for example along the Gualala and Navarro rivers. Because of the mesic (moist) local climate, tree species which are limited to riparian habitats in drier parts of the state often extend into upland areas in this region, e.g., Big-leaf Maple, and upland conifers grow in the riparian zone. Redwood attains its maximum growth on coastal river flood plains.

The Eel, Smith and other large rivers and streams of the northwest created alluvial plains and deltas at their ocean mouths. At one time these delta plains were sites of thick black cottonwood, willow and red alder forests, often mixed with Sitka spruce and redwood (Ray et al., 1984). All the thickest and most productive forests which formerly existed in the North Coast/Klamath region were cleared for agriculture and urbanization, and in the coastal plains of Humboldt and Del Norte counties, extensive areas of redwood and Sitka spruce were logged for timber. The flood plains of the Russian and Napa rivers are renowned for their vineyards, now growing where riparian woodlands once stood. Along rivers flowing through narrow and frequently scoured channels, riparian habitat remains substantially in its natural state, except for localized impacts due to logging, mining, grazing and other development activities.

The North Coast/Klamath region is known for its salmon and steelhead—resources long important to humans in the region. As narrated in Chapter 1, much Native American culture centered around rivers and their fish, with salmon the most important harvest. There are no reliable estimates for historic fish abundance, but from all descriptions it was enormous. The region's major salmonid species include chinook and coho salmon, steelhead and coastal cutthroat trout, and resident trout in headwater areas. The rivers of northwestern California support about one-third of the state's chinook, almost all of the coho and steelhead, and all of the coastal cutthroat.

Coniferous forests are predominant over the area, and timber harvest is the main land use. As a consequence of logging, massive surface erosion and landsliding have occurred, drastically increasing sediment delivery to downstream channels. Although most existing impacts were due to past, unregulated forest practices, there is still a significant threat from modern logging due to cumulative watershed effects.

During the 1800s, the plentiful fisheries resource of this region attracted Americans from the East and European immigrants. After the start of the Gold Rush, salmon were exploited at unsustainable rates by in river netting. Such early commercial harvest, coupled with habitat destruction by logging, nearly destroyed the salmon fisheries of the North Coast. With the advent of fishing regulations, populations were able to stabilize, and even recover, to a large degree (See Chapter 1). However, much of the habitat damage from the earliest logging remains.

Because of the steep terrain, human settlements and roads are concentrated in river valleys, and are thus subject to frequent flood damage. The great floods of 1956 and 1964, exacerbated by huge amounts of logging debris and sediment, wiped out many small villages and significantly altered river ecosystems of the area.

Anadromous fish once ran all the way up the Klamath River system into Oregon. With the construction of Iron Gate Dam (1917-1922) a drainage area of about 4,300 square miles was no longer available to runs of chinook salmon and steelhead trout. Dams and diversions on the upper Klamath, Scott and Shasta rivers have resulted in decreased flows and increased water temperatures. Agricultural drainage returns in these areas today cause additional water quality problems. The Trinity River main stem was dammed in 1963 by Lewiston Dam, blocking significant upstream spawning areas. More dramatic was the dam's ultimate effect of allowing the diversion of up to 90 percent of the flow of the river out of the basin for transfer to the Central Valley Project via the Sacramento River. The anadromous fisheries declined by 90 percent soon thereafter. Hatcheries for mitigation exist at Iron Gate and Lewiston dams, but cannot make up for the loss of wild production.

Instream gravel mining is increasing in the region, and its effects on geomorphology and biological resources only recently are being documented. On the Mad and Russian rivers, aggregate extraction has resulted in extensive degradation (downcutting) of the river channels, which has damaged aquatic habitat and riparian vegetation, undermined bridges and impaired water supply availability. The counties of Humboldt and Sonoma are beginning to address the cumulative impacts of sand and gravel mining on these rivers.

Even though the northwest is still famous for its fishery resource, the area has experienced at least 80 percent declines in salmon and steelhead since the 1950s (California Advisory Committee on Salmon and Steelhead Trout, 1988). Many native salmonid stocks are considered at risk of extinction (Figure 49). Historically, the Klamath River Basin chinook runs were in the hundreds of thousands; in 1990 and 1991 the in river population was just over 30,000, a 90 percent decline. The Shasta River is the most important chinook spawning tributary in the upper Klamath River system. Its chinook run has declined from recent averages of 30,000 (a historic high was over 60,000) to a count of 700 in 1991 (PFMC, 1992).

The coho, steelhead and coastal cutthroat have also suffered population declines. The coho, summer-run race of steelhead and coastal cutthroat are all California Fish Species of Special Concern (Moyle et al., 1989).

The Klamath River supports California's largest spawning run of eulachon (candlefish), a native anadromous smelt. Eulachon (from its Indian name, pronounced "oolak-on") are an important prey fish for ocean, estuarine and river birds, mammals and fish. Eulachon are quite oily and when dried were used as candles by northwest Indians. They were an important food fish as well (Moyle, 1976).

Figure 49. Anadromous Salmonid Stocks at Risk in Northern California.

A=High Risk; B=Moderate Risk; C=Stock of Concern

Source: Humboldt Chapter, American Fisheries Society (Higgins, 1992)

Figure 50. South Fork of the Trinity River.

Case Study: South Fork of the Trinity River

The longest free-flowing wild river in California is the South Fork of the Trinity River, flowing 90 miles from its headwaters in the Yolla Bolly Wilderness to the confluence with the Trinity River. The lower 53 miles of the South Fork is designated as a segment of the state and federal Wild and Scenic River Systems.

The primary basis for inclusion in the Wild and Scenic system was the anadromous fisheries resource. Seven different species or stocks are known to use the South Fork, including summer steelhead, winter-run steelhead, spring-run chinook salmon, fall-run chinook, coho salmon, chum salmon and Pacific lamprey (U.S. Forest Service, 1992). Spring and fall chinook and summer steelhead on the South Fork are currently considered to be at high risk of extinction (Higgins et al., 1992). Chum salmon are a widely distributed and abundant Pacific salmon species, but are quite rare in California. The South Fork Trinity is one of the three rivers which still have chum spawners (Moyle and Yosiyama, 1992).

Much of the South Fork Trinity watershed lies over geologic formations which produce soils and terrain that are highly unstable, and are susceptible to surface erosion and large landslides (U.S. Forest Service, 1992). In the late

Continued on next page.

1950s and early 1960s, much of the watershed was logged, with little regard for the effects of altering the drainage network or removing vegetative cover. In 1964, a massive flood event wreaked havoc with the South Fork watershed (as it did in much of the North Coast region). Huge amounts of sediment and debris washed downslope, filling tributaries as well as the South Fork's main channel.

Historically, the South Fork contained many large, deep pools. These provided excellent habitat for holding summer steelhead and spring chinook over the dry season until fall and winter spawning (Higgins et al., 1992). In the 1964 floods, millions of cubic yards of sediment eroded into the river, filling pools, destroying riparian vegetation and otherwise damaging river habitats. In some areas, up to 25 feet of channel aggradation occurred. Today, some of the sediment has washed out of the system, which is slowly recovering. However, the devastating effects of 1964 still plague the fishery.

Lightning caused fires in 1987 burned thousands of acres in the South Fork Trinity watershed. Following the fires, the U.S. Forest Service proposed to carry out sanitation-salvage logging on the burned lands, under the South Fork Fire Recovery Salvage Project. The USEPA and the North Coast Regional Water Quality Control Board both objected to the logging on the basis that timber harvest and road building would cause significant adverse impacts on an already stressed system. The Forest Service ignored these objections. A coalition of environmental and fishing groups, including the Wilderness Society, Sierra Club, Pacific Coast Federation of Fisherman's Associations, Inc., and California Trout, Inc., brought suit against the Forest Service to halt the logging under provisions of the federal Wild and Scenic Rivers Act. The winning bidder for the proposed sale, Sierra Pacific Industries, Inc., intervened on the side of the Forest Service.

A temporary restraining order was imposed in the fall of 1988 which halted the timber sale and logging, followed by a preliminary injunction several months later. After various legal appeals and orders, several years passed, still with no logging having occurred and the preliminary injunction in place.

One of the most important issues to be considered in granting a preliminary injunction is

Continued on next page.

whether "irreparable injury" could result if the action in question is allowed to proceed. Both sides of the dispute produced expert testimony which offered differing interpretations of the facts about the impacts of the proposed logging on river resources. In February of 1992, the court finally appointed its own expert to sift through the scientific testimony which had been presented by both sides. Dr. R. Dennis Harr, an employee of the Forest Service from Seattle, concluded that the logging would produce a limited amount of sediment to the river, which by itself would not be expected to irreparably harm salmonid resources of the river. However, Dr. Harr also concluded that sedimentation from the salvage logging taken *cumulatively* with the amounts that would occur from the watershed in general, and the amounts already present in the river system, would indeed cause significant and irreparable harm to steelhead and salmon populations in the South Fork Trinity.

In the spring of 1992, the U. S. District Court denied motions to dismiss the preliminary injunction, citing in part the findings by the court's expert on cumulative impacts. In the fall of 1992, the notice of appeal of the court's decision was dismissed, and the timber sale was withdrawn.

Table 5. Major Rivers in the Klamath/North Coast Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Albion	14	65
Bear	25	120
Big	40	180
Black Butte	25	130
Eel	200	3,120
Elk	17	80
Garcia	32	110
Gualala	35	290
Klamath	210	12,100
Little	17	40
Mad	90	490
Mattole	56	340
Napa	55	426
Navarro	19	300
New	25	220
Noyo	35	130
Petaluma	25	140
Russian	105	1,480
Salmon	46	750
Salt	8	20
Scott	68	650
Shasta	52	790
Smith	50	630
Ten Mile	10	110
Trinity	170	2,860
Van Duzen	63	275

Kreissman, 1991.

Figure 51. Central Valley Region.

Central Valley Region

The Central Valley region includes the drainage area of the Sacramento River (to Shasta Dam) and San Joaquin River systems, and the rivers which flow into the Tulare Basin in the southern San Joaquin Valley. Rivers which are part of the natural Sacramento River watershed but are now cut off by Shasta Lake are discussed in the Modoc/Cascade region section (e.g. Pit, McCloud).

The Central Valley is dominated by the Sacramento and San Joaquin rivers, which join together in the Delta to flow into San Francisco Bay and eventually into the Pacific Ocean. These are the state's largest rivers with historically the most extensive riparian systems and greatest fish resources. The southernmost rivers in the San Joaquin Valley (the Kern, Tule, Kaweah and Kings) do not actually flow into the San Joaquin River, but flow into two closed basins at the south end of the valley; their flows are heavily diverted to support agriculture.

The rivers in the region flow from the Sierra Nevada mountains, traverse the range in high gradient channels cut into steep canyons, pass through the foothills, and emerge onto the valley floor. With the decrease in channel gradient, the rivers adjust to a more sinuous, meandering pattern, flanked by broad flood plains which formerly supported extensive riparian forests. Thus, the same rivers display very different characteristics along their length. Runoff is derived almost exclusively from the higher elevations, and seasonal runoff patterns reflect both snowmelt and rainfall runoff peaks.

The headwaters of the Sacramento and San Joaquin rivers (and their tributaries) receive 60-80 inches of precipitation annually, but the valley floor itself is quite dry, increasingly so to the southern end. Red Bluff receives 24 inches of rain, Stockton receives 13 inches of rain annually, and Bakersfield receives only six.

Mature riparian forests of the Central Valley are California's version of a rain forest jungle. Lush growths of riparian trees and shrubs contribute a high amount of standing biomass and primary productivity. Measurements of biomass (basal area) for the Central Valley riparian forests (Conard et al., 1977 and Strahan, 1984) are comparable to amounts indicated for a variety of flood plain and swamp forests of the eastern United States (see data compiled by Brinson et al.,1981, p 29; Holstein, 1984). It is likely that California lowland flood plain riparian forests—with optimal conditions of high sunlight, water and regular infusions of nutrients—have ecosystem productivities even higher than tropical rain forests (Major, 1977).

Katibah (1984) has estimated that the Central Valley floor historically contained about 922,000 acres of riparian vegetation, including growth along the Sacramento and San Joaquin rivers, their tributaries, and the rivers and streams of the southern San Joaquin Valley such as the Kern, Kings and Kaweah. Warner (1985) estimated riparian vegetation covered a total of 1.6 million acres for the Central Valley, suggesting that the amounts given by Katibah for the area from the Kings River south were too low. As of the early 1980s, about 102,000 acres in the valley remained, with about one-half that in a highly degraded condition (Katibah, 1984), a decline of 90 percent or more.

The largest salmon runs in the state were from the Sacramento/ San Joaquin river systems, estimated at up to 1 million fish in peak years, with average yearly runs at 600,000 (DFG, 1991a). Historically, of the four races of chinook salmon in the Central Valley (winter, spring, fall and late-fall runs), the spring-run was the most abundant. Before the recent drought, chinook river populations in the Central Valley averaged about 272,000; over 85 percent of this consisted of fall-run from the Sacramento River (Reynolds et al., 1990).

With the exception of the Cosumnes River, all Central Valley rivers of any size have been dammed in the foothills. Some of these dams were constructed by local irrigation or municipal water districts, but the biggest structures were erected either as part of the CVP of the U.S. Bureau of Reclamation in the 1940s or the SWP of the Department of Water Resources in the 1960s. In addition to these large foothills reservoirs, most basins have a network of smaller dams and diversion canals for hydroelectric generation in their upper watersheds.

The construction of dams in the foothills has effectively prevented anadromous salmonids from reaching natal spawning grounds upstream. Before water development, there were about 6,000 miles of anadromous fish spawning habitat in the Central Valley. In a steady progression of water project developments, valley rivers were picked off one at a time and their waters dammed and diverted for flood control, power generation and water supply. Less than 300 miles of spawning area remain—just five percent of the historic amount (California Advisory Committee on Salmon and Steelhead Trout, 1988). Also, irrigation siphons, intake pipes and high-capacity diversion pumps along valley waterways, including the Delta, directly kill millions of salmon eggs, larvae and young, and other fish resources every year. There are an estimated 300 intakes on the Sacramento River and 1,800 in the Delta. Only a handful are screened, and those still cause significant mortality of fisheries (Reynolds et al.,1990).

Sacramento River

The Sacramento River drains 24,000 square miles, and is so large that it is in a class by itself among California rivers. Along its length, the river geomorphology varies. From Redding to Red Bluff (River Mile 302-243), the river channel is naturally constrained by resistant geologic formations on both banks. From Red Bluff to Hamilton City (RM 243-194), the channel freely meanders, flanked by a wide flood plain. From Hamilton City to Colusa (RM 194-143). The river once naturally meandered between natural levees built up

Figure 52. Sacramento River Between Levees.

during overbank floods, but now is somewhat constrained by setback levees and bank protection. Downstream of Colusa (RM 143-0), the river flows through a completely channelized reach, narrowly constrained by artificial levees built for flood control (Figure 52).

At the time of statehood, there were an estimated 500,000 acres of riparian vegetation bordering the Sacramento River main stem (Upper Sacramento River Advisory Council, 1989; Katibah 1984). Diaries and notes from observers at the time described these riparian forests as luxuriantly green and dense, dominated by stately oaks, sycamores and cottonwoods. In just a few decades after 1850 most of the riparian forests were decimated by fuelwood cutting. From the turn of the century on, agricultural clearing and flood control projects added to the losses (Thompson, 1961).

By 1979, woody riparian habitat along the Sacramento had decreased to 11,000-12,000 acres, about two percent of historic levels (McGill, 1979). Interestingly, from 1982 to 1987, riparian vegetation incrementally increased to about 16,000 acres, including an addition of several thousand acres into high terrace climax vegetation (McGill, 1987). This recent increase probably reflects the combination of a decline in agricultural economies and natural riparian plant succession.

The Sacramento River's main flow is regulated by Shasta Dam and by water transfers from the Trinity River, both part of the federal CVP, which have increased summer base flow (to supply agricultural diverters) and reduced winter and spring peak flows. The Feather and Yuba rivers, two major tributaries to the lower Sacramento, are also controlled by dams.

Shasta Dam (constructed 1938-1944) blocked the entire upper Sacramento, McCloud and Pit river systems, which were the principal spawning grounds for chinook salmon and steelhead. The remnant salmon population of the Sacramento system must spawn in the main stem below Shasta Dam, in the remaining undammed tributaries (such as Battle and Cottonwood creeks), and below dams on major tributaries. However, spawning in the main stem is severely limited by a lack of suitable spawning gravel. The lack of gravel has several causes. Shasta Dam traps all gravel that would normally travel downstream from the watershed, so flood flows scour gravel away without bringing in a fresh supply. Another cause is the extensive mining of gravel from the bed of the main stem and from its principal tributaries, which formerly supplied fresh gravel to the main stem. An additional source of gravel to the channel is erosion of gravel from river banks as the channel naturally migrates across its flood plain. Further bank protection works threaten to eliminate this important source of gravel.

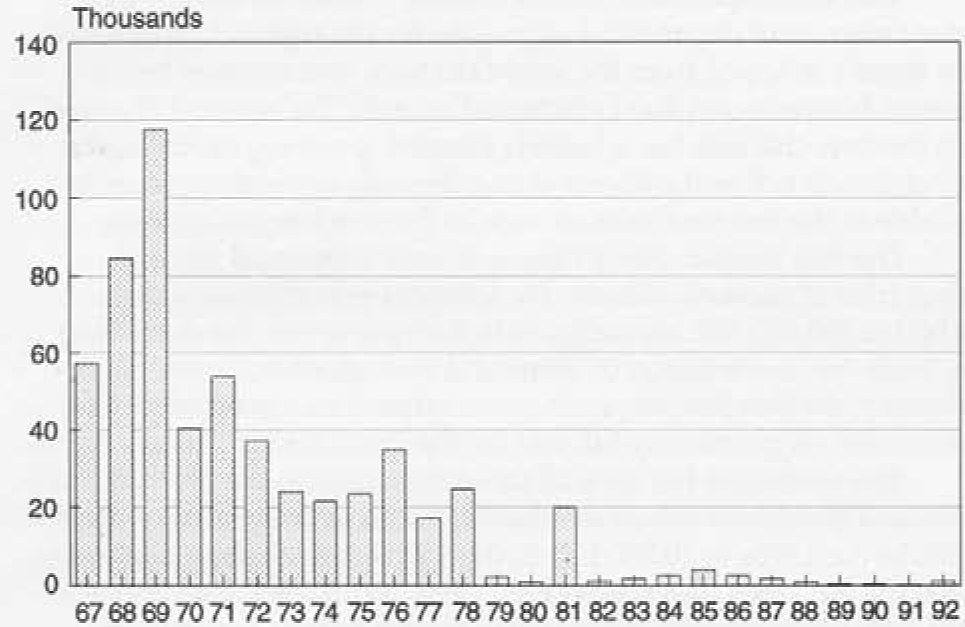
The Feather River system was formerly a world class fishery; earlier in this century, fishing resorts along the North Fork Feather attracted European nobility and other enthusiasts to fish for its remarkable runs of spring and fall-run salmon. Water development on the North Fork Feather started in about 1913, and today it is stair-stepped with dams and reservoirs built by the Pacific Gas & Electric Company. Fish ladders were either not effective or nonexistent. Since the construction of Oroville Dam in 1968, good fishing is now restricted to the reach below the dam, mainly supported by a hatchery. In addition to inadequate spawning gravels, this reach suffers from episodic pulses of flow released from the dam.

The Yuba River is the Feather's main tributary. Although the Yuba is blocked about 25 miles upstream by an impassable dam, there have been sufficiently good channel and flow conditions downstream of the dam in many of the years to support spawning runs of salmon and steelhead. With the latest climatological dry cycle, as in other dry years, flows in the spring are far less than optimal for salmonid survival and migration (Reynolds et al., 1990). Gold dredging has severely altered the Yuba flood plain. Today the Yuba is still worked by miners, who divert river flows into a vast area of dredger tailings and ponds, compounding impacts to fish.

In the Sacramento River system every life history stage of chinook salmon is present every month of the year, a unique feature among California river systems. The Sacramento fall-run is now the most numerous race in the Central Valley, but its numbers have been trending downward since accurate records have been kept, and have declined severely under the latest dry cycle.

The spring-run has only about 1,000 spawners and is at high risk of extinction (Nehlsen et al., 1991). This race is listed as a Species of Concern by the California Department of Fish and Game. In 1991 winter-run was estimated at less than 200 fish, and just over 1,000 fish were counted in 1992. It is listed as Threatened under the federal Endangered Species Act and as Endangered under the state act. This race may have numbered about 200,000 before the construction of

Figure 53. 25 Years of Winter-run Salmon Counts on the Sacramento River at Red Bluff Diversion Dam.



Shasta Dam (Harry Rectenwald, DFG, cited in NMFS, 1991). Since the construction and operation of Shasta Dam, the highest population was estimated at 117,808 in 1969, a year before the construction of Red Bluff Diversion Dam, but has declined since that time to its present status (Figure 53).

The effect of this listing has impacted the California ocean troll and recreation fisheries and is expected to continue until the species has recovered (PMFC, 1992). This listing has only marginally impacted the amount of water diverted from the Sacramento-San Joaquin Delta by the SWP or the CVP. During the spring of 1992, significant winter-run smolts were lost (estimated at about 10,000 juvenile winter-run; Deborah McGee, DFG, pers. comm.) with the majority lost at the SWP's Banks Pumping Plant.

San Joaquin River

The San Joaquin main stem has been dammed since 1949 by Friant Dam, part of the CVP. Construction began in 1939 and the dam was fully operational by 1949. The San Joaquin has virtually dried up below Friant, resulting in devastation of the fishery. Flow in tributary rivers—the Stanislaus, Merced, and Tuolumne—has also been regulated and reduced, primarily by diversion for agriculture. For example, the Merced River's natural seasonal flow pattern has been altered, with high snowmelt peaks reduced and flows augmented over the summer irrigation season. In most years, and certainly during the latest dry cycle, flows have been inadequate in the three tributaries for the spawning, rearing and emigration of salmonids.

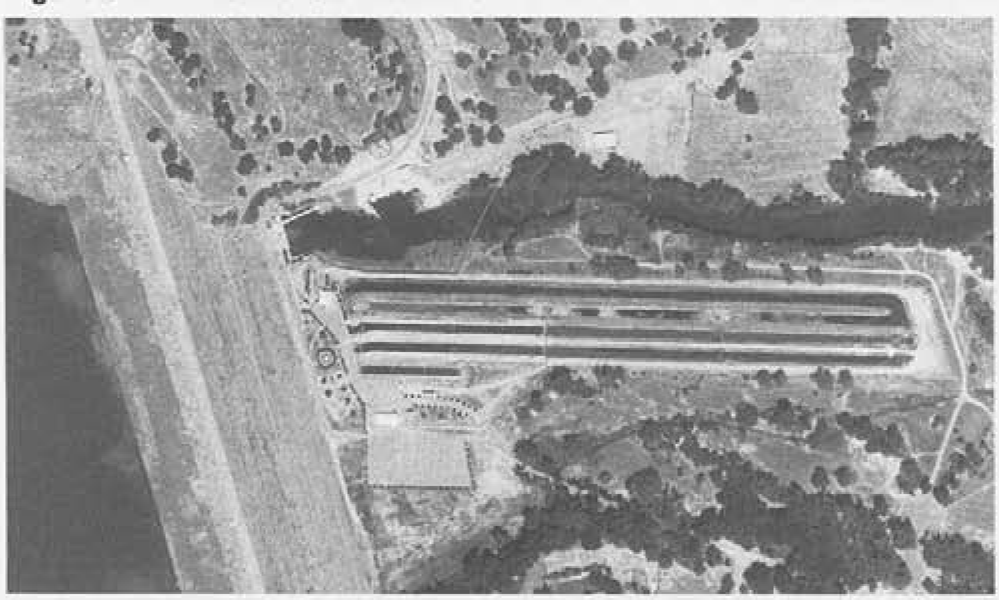
The San Joaquin main stem and major tributaries have been important sources of commercial aggregate for the region. Gravels have been largely stripped from the active channel, and are now being removed from adjacent flood plains and terraces. The removal of gravel from the river channels has adversely affected spawning habitat in the river channels below the lowest dams, the only spawning grounds available to the remnant salmon runs in the San Joaquin system.

The San Joaquin River drainage once supported fall and spring-runs of chinook salmon. Escapement was estimated at from 100,000 to 300,000 fish annually, with the spring-run the dominant run. With the construction of dams and diversions on every major waterway, the San Joaquin spring-run salmon was extirpated. The system now supports only fall-run on the three main tributary rivers.

The combined fall-runs of chinook salmon to the Merced, Tuolumne and Stanislaus Rivers declined from an average escape-ment of 72,000 in the 1940s to 10,700 fish in the 1970s, rebounding slightly to 32,000 for the 1980s (Reynolds et al., 1990). With the latest dry cycle (1987-1992), San Joaquin Valley chinook numbers are only in the hundreds and are at severe risk of extinction. The runs for the San Joaquin basin were down to about 600 naturally spawning fish during 1991 (PFMC, 1992).

It should be noted that during the years 1981 through 1986 the San Joaquin system spawning runs of chinook salmon were in excess of 30,000 fish with a high of 70,000 fish in 1985. The high returns of 1983-1985 are believed to be the result of fortuitous high spring run-off and Delta outflow conditions during the previous two years (Reynolds et al., 1990).

Figure 54. The Mokelumne River.



Case Study: Mokelumne River–
Toxic Mine Drainage

The Mokelumne River, along with the Cosumnes and Calaveras rivers, is directly tributary to the eastern Delta, without joining the Sacramento or San Joaquin rivers. The Mokelumne drains from the western slope of the Sierra Nevada and runoff is primarily from snowpack in the upper watershed.

The Mokelumne once supported a large spring-run salmon population, as well as fall-run chinook and steelhead. In 1929, the East Bay Municipal Utility District (EBMUD) constructed Pardee Dam in the Sierra foothills, allowing the diversion and pipeline transport of water to the EBMUD service area. The dam blocked access to the cooler upstream spawning waters necessary for the spring-run, and this stock was extirpated. There was no mitigation for fish losses due to Pardee. In 1963, EBMUD constructed Camanche Dam and reservoir downstream of Pardee to enable the district to better meet downstream riparian water rights. This dam and reservoir ruined much of the remaining spawning grounds for the fall-run chinook and steelhead stocks which had survived after Pardee Dam. This time, a hatchery was built for fishery mitigation, situated below Camanche Dam.

EBMUD derives 95 percent of its water supply from the Mokelumne River, a source famous for its outstanding quality. The district's current water right entitles it to one-half of the average annual runoff from the river system, although its current average annual diversion is about one-third. Instream flows for fish are currently only required for the hatchery below Camanche, in an amount of one to two percent of the total runoff. Fishery resources have plummeted since Pardee and Camanche dams went in and the hatchery has not been successful at mitigating losses. The disparity in the flows fish get and what they need is illustrated in part by the draft management plan released by California Department of Fish and Game which calls for up to 28 percent of runoff to be dedicated to fish.

Lawsuits have been filed by environmental organizations, and several different government bodies have begun various hearings and investigations into

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EBMUD's water rights and project operations to look at whether improvements are necessary in managing Mokelumne flows for environmental protection.

There are many troublesome issues to contend with on the Mokelumne, including: water allocation among competing users; the protection of the public trust resources in the river; possibly changing the point of EBMUD's diversion to the Delta; and providing high-quality drinking water to the district's customers. However, all of these water supply questions are made extraordinarily more difficult by the presence of another, seemingly unsolvable problem—toxic runoff from the abandoned Penn Mine. The environmental problems have been accompanied by charges from environmental groups, notably the Committee to Save the Mokelumne, that government agencies have mismanaged the situation.

Figure 55. Penn Mine on the Mokelumne River.

Penn Mine is an old copper and zinc mine located in Calaveras County between the present site of Pardee and Camanche dams, on slopes which drain to the Mokelumne (Figure 55). The mine was opened in 1861 and operated steadily until 1919, and then intermittently until the 1950s. Copper and zinc ore were mined from underground shafts through the mountains, and more than 55,000 linear feet of shafts still honeycomb the hills. Rainwater

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reacts with sulfides in the ores exposed by mining to produce sulfuric acid at battery acid or worse levels. This strong acid in turn dissolves heavy metals such as cadmium, zinc and copper, which are highly toxic to aquatic life and to humans.

Before the construction of Pardee, toxic mine leachate ran straight into the river, affecting aquatic biota, but unimpaired flows diluted and flushed toxic substances downstream. When the river was dammed and flows were diverted, dilution and flushing were decreased. In 1937, following a flushing of some of the mine shafts, the first recorded fish kill occurred, sterilizing the river for 60 miles downstream. Other fish kills have happened through the years.

In 1964 Camanche Dam was completed, creating in effect a storage trap for toxics, but fish kills and sublethal toxic effects still continued with regularity on the river below Camanche Reservoir. In 1977, after a drought period, the water levels in Camanche had dropped substantially. This exposed a mud flat loaded with high concentrations of toxic heavy metals. EBMUD released a sudden flush of water from Pardee, which stirred the toxics into solution, wiping out fish life in the reservoir, the river and the hatchery. EBMUD, which owned much of the property at the Penn Mine site and operated the two reservoirs, was ordered by authorities to clean up the toxic problem (Figure 56).

Following many negotiations, enforcement action was dropped against EBMUD, and the district and the Central Valley Regional Water Quality Control Board (CVRWQCB) cooperatively built what was thought to be a solution to the problem. However, the system of holding ponds and other facilities installed at the mine site has, allegedly, never performed adequately. Experts hired by environmental groups contend that the problem was even exacerbated by the remediation project. The environmental groups further allege that information on the supposed remediation action was suppressed by government agencies and they have filed a number of lawsuits.

Currently there are actions pending in court and in various government agency hearing and permit processes, looking at water allocation and toxic remediation.

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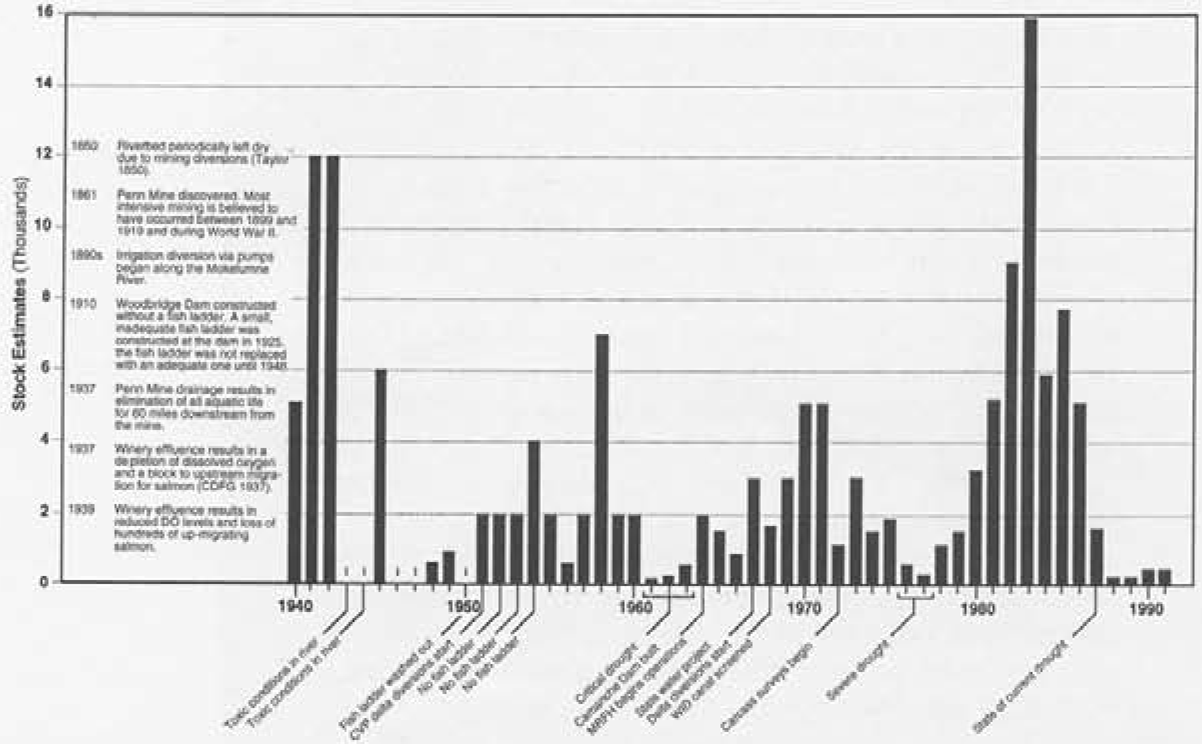
Figure 56. Mokelumne River Salmon Stock Estimates and Important Environmental Events, 1850-1991.



Note: 1 No official estimates

Source: BioSystems Analysis, Inc./ EBMUD-EIR

In March 1993, a U.S. District Court judge ruled that EBMUD and the CVRWQCB were in violation of the federal Clean Water Act due to the toxic discharges from the "remediation" facility. EBMUD has steadfastly maintained that it is not culpable for problems dealing with the fishery resource, and is fighting attempts to significantly alter water rights and other permits for their activities on the Mokelumne.

The above information was taken from papers prepared by the Committee to Save the Mokelumne, articles in the December 2, 1991 *Sacramento Bee*, and articles in the September 28 and 29, 1992 *San Francisco Daily Journal*.

Table 6. Major Rivers in the Central Valley Region.

River	Length (mi.)	Watershed Area (sq. mi.)
American	265	2,000
Bear (Feather)	77	295
Bear (Mokelumne)	20	60
Calaveras	80	365
Chowchilla	65	250
Clavey	35	170
Cosumnes	80	725
Downie	20	40
Fall (Feather)	25	40
Feather	175	4,580
Fresno	75	240
Kaweah	77	720
Kern	164	2,400
Kings	133	1,745
Merced	135	1,275
Middle	30	—
Mokelumne	160	660
Old	48	—
Rising	5	—
Roaring	17	80
Rubicon	65	315
Sacramento*	327	24,000
Saint Johns	25	—
San Joaquin	330	13,540
Stanislaus	161	1,100
Tule	91	395
Tule-Little Tule	149	1,900
White	55	850
Yuba	96	1,350

*Includes above and below Shasta Dam.

Kreissman, 1991.

Figure 57. Modoc/Cascade Region.

Modoc/Cascade Region

The Modoc Plateau/Cascade Range region, a rugged and isolated part of the state, is drained by the Pit, McCloud and Upper Sacramento rivers, tributaries to the Sacramento River. The upper reaches of the Sacramento system now end in Shasta Lake, the reservoir created by the CVP's Shasta Dam.

This region is underlain by volcanic rocks and its two principal rivers, the McCloud and Pit, are notable for their cold, steady flows fed by prolific springs which issue from the slopes of volcanic mountains. The rivers are typically incised into steep-sided canyons within the volcanic uplands, and riparian habitat is limited. The steady base flows are augmented by snowmelt runoff in early summer, although the seasonal variability is much less than that displayed by rivers in other regions of the state. Precipitation is generally low, except on the high volcanic mountains, notably Lassen and Shasta. The Pit River as it passes through the mountains gets an average annual precipitation of 75 inches, but Alturas receives only 13 inches annually. Most of the snowfall on the mountains infiltrates into the permeable volcanic rocks and reemerges as spring flow.

Prior to the construction of Shasta Dam, the Upper Sacramento, McCloud and Pit rivers supported vast runs of anadromous salmonid. The clear, cold, steady spring flows provided ideal spawning and rearing habitat for salmon, and supported runs of hundreds of thousands of fish, primarily spring-run (Reynolds et al., 1990). The McCloud was the historic spawning grounds for the now-endangered winter-run Chinook. With construction of Shasta Dam in 1940, sea-run fish could no longer reach these sites, and entire races adapted to the specific conditions of particular rivers dis-appeared. Shasta Dam eliminated one-half of the natural spawning and rearing habitat for salmon and steelhead in the Sacramento River system (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council, 1989). Ironically, the first fish hatchery in California was built in 1872 on the McCloud River for chinook salmon; the site was later flooded by Shasta Lake reservoir (Hedgpeth, 1991; Higgins, 1991) (See "The Wintu Fishery" box).

The resident fisheries of the Upper Sacramento River and its tributaries (the Pit, McCloud and Fall rivers) are of still tremendous importance, since rainbow and the introduced brown trout are still much sought-after as game fish.

The lower Pit River is now heavily developed for hydroelectric power production, and much of its course is a staircase of hydroelectric power plants, impoundments and diversion canals. Aquatic habitats have been drastically altered.

The upper Pit River and its tributary, the Fall River, flow through the relatively flat Modoc Plateau country. Here watercourses are bordered by marshy and wet meadow areas, with relatively small amounts of woody riparian vegetation. Several rare fish are found in the Pit system, including two species of sculpin and a state and federally listed Endangered invertebrate, the Shasta Crayfish. Grazing is a major cause of adverse impacts on riparian and aquatic habitats in this area.

At the extreme northern end of the state, the Lost River system lives up to its name in more ways than one. It originates in Clear Lake Reservoir, flows out of California into Oregon, then returns back to California ending in Tule Lake. The Lost River drainage supports a unique fish fauna, including the state and federally endangered Lost River Sucker and Shortnose Sucker. Habitat alterations by agriculture, water diversions and grazing have severely threatened these and other native aquatic species in the far northern part of the state.

Figure 58. Fishing the Fall River.

Source: California Trout, Inc.

Case Study: Fall River

The Fall River, in northeastern Shasta County, is only 25 miles long but is of statewide importance as the site of an often cited court decision involving the public's rights to use navigable waterways.

The Fall River originates from an area called Thousand Springs, near the small town of Dana. These

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headwater springs produce a relatively high and constant flow in the Fall River, with a summertime average of about 450 cfs (Rode and Weidlein, 1986). Winter high water does not peak at very high rates; the 10-year flood event flow is about 4,000 cfs (Jones and Stokes, 1992). (Compare this with the Eel River, with an August average flow of only 150 cfs and 10-year flood events of over 340,000 cfs (Jones and Stokes, 1981).

The Fall River follows an extremely sinuous path as it meanders through the Fall River valley to its confluence with the Pit River near the town of Fall River Mills. The valley is primarily wet meadows and grassy fields used for pasture and hay production. Woody riparian vegetation along the river occurs in minor amounts. Almost all of the valley, including the river shore zone, is in private ownership.

The river's stable flows and water temperatures support a fish fauna renowned for both sport fishing and for biodiversity. Native rainbow trout are abundant and are managed as a game fishery under the California Department of Fish and Game Wild Trout program. The Fall River also supports the Rough Sculpin, the Bigeye Marbled Sculpin and the Shasta Crayfish, all special-status species.

The Fall River is nationally famous among anglers for its wild trout fishery. Essentially all fishing is done from boats on the river, due to the private ownership on the shore. Additionally, the meadows and wetlands of the Fall River valley attract migratory waterfowl and hunting is popular. About 20 percent of the hunters hunt from boats on the river. Public access to the river is limited to only a few launch areas. Boats large enough to require trailering can only put in at one location, the boat ramp at Big Lake, which is upstream on the Tule River, a tributary to the lower Fall River. There are also a handful of private access points at resort lodges which charge a fee (Rode and Weidlein, 1986).

A low-clearance county bridge on Island Road on the lower third of the river effectively keeps large power boats from the upper river, but small boats can freely pass under. Despite the lack of access points, the Fall River is currently used heavily by the boating public for fishing, hunting, nature observing, water-skiing and cruising (Jones and Stokes, 1992).

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Free use of the Fall River was not always available. Prior to 1950, fishing and boating were generally allowed along the river. Then, in the early 1950s, private landowners along the river erected booms, fences and low bridges across the river and fences along the river to prevent access to and over the waterway. In 1964, the state, represented by Shasta County District Attorney Robert Baker, sued for an injunction to prevent private owners from interfering with public use of the river. The trial court found the segment of the river in question to be navigable in fact, and issued the injunction. The defendant private property owners appealed, and the Court of Appeal affirmed the original decision. The appellate decision, *People ex rel. Baker v. Mack* (1971) 19 Cal. App. 3d 1040, is an important reaffirmation of the public's rights to boating, fishing, hunting and related activities upon navigable waterways. Equally important, or perhaps more so, was the finding that a waterway is navigable for purposes of public use if it is capable only of pleasure boating. Commercial navigation is not necessary in order for the public's rights to apply. The court further held that ownership of title to the bed of the Fall River was irrelevant to the question of whether or not public navigation rights existed. Those rights exist on bodies of water which are navigable in fact irrespective of ownership of the underlying land, as long as access to the waterway can be gained legally.

Recently an interesting situation has arisen on the Fall River which must employ the principles set forth in *Baker v. Mack*. In 1945, the Island Road Bridge, mentioned above, was constructed midway on the Fall River. By the late 1980s, this wooden structure had deteriorated to the point that it needed to be replaced. (Background information on the Island Road Bridge project in the following was taken from Jones and Stokes Associates, Inc., 1992).

Shasta County Department of Public Works and the Federal Highway Administration circulated a draft Initial Study/Environmental Assessment for the bridge replacement which compared three alternatives for bridge reconstruction; one with 3.5 feet clearance underneath, which was the same elevation above normal summer flow levels as the original; one with 6.5 feet clearance; and one with 14 feet of clearance. The proposed alternative ended

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up being the smallest of the choices, replacement at the same height as the existing bridge.

One citizen, represented by counsel, commented to Shasta County's environmental document that the original Island Road Bridge, by preventing larger boats from passing, was a "public nuisance" (citing *Baker v. Mack*, among other cases). The commentator noted that the other alternatives for increased bridge height, albeit more expensive, would reduce or eliminate this "nuisance." The county disagreed, responding that Civil Code § 3479 defines a nuisance as "Anything which . . . unlawfully obstructs the free passage or use, in the customary manner, of any navigable lake, or river, bay, stream, canal, or basin." The selected alternative would result in the same type of usage as the current situation which the County deemed to be the customary situation.

Interestingly, the California Department of Fish and Game also supported the alternative of the lowest height, on the basis of protecting the fishery resource, both for the Wild Trout Management program and the special status aquatic species. The County has proceeded to file a Notice of Determination approving the replacement of the bridge at its original height.

Table 7. Major Rivers in the Modoc/Cascade Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Fall (Pit)	25	—
Lost	26	—
McCloud	60	600
Pit	200	5,000
Sacramento*	327	24,000

*Includes above and below Shasta Dam.

Kreissman, 1991.

Figure 59. Central Coast Region.

Central Coast Region

The Central Coast region lies within the southern Coast Ranges, from San Francisco Bay south to the Santa Ynez River in Santa Barbara County. It includes the Central Coast Basin and southern portion of the San Francisco Bay Area Hydrologic Basin. In this region, mountain ranges alternate with elongated alluvial valleys, such as the Pajaro, Salinas, Santa Maria and Santa Ynez river plains.

Mountains and foothills of the Central Coast are wooded or chaparral-covered, while the large alluvial valleys (e.g., Salinas, Santa Maria) are mainly agricultural. The Central Coast is one of the state's leading areas of range and pasture livestock production (California Department of Forestry and Fire Protection, 1988) and agriculture.

Rainfall is generally low in the valleys. For example, Salinas has an average annual rainfall of only 14 inches. The higher mountains receive considerably more, such as the Santa Cruz Mountains above the city of Santa Cruz, with over 60 inches of annual precipitation. Rainfall and runoff are highly seasonal, with nearly all rainfall between November and April, 60 percent falling in December, January and February. River flows show comparable variability, with high winter flows (in direct response to intense rainstorms) and low summer base flow.

Central Coast rivers maintain a base flow in their mountainous reaches. Under natural historic conditions, base flow was sustained over the length of their alluvial valleys through all but the longest of droughts (and maintained high alluvial water tables throughout). However, valley base flows have been reduced (or eliminated in most years) by human extraction of underflow (which is shallow ground-water recharged by the river). Along the Carmel River, municipal supply wells dropped the water table below the rooting depth of willows, resulting in an extensive die-off of willows, loss of bank protection afforded by the vegetation, and locally massive erosion (Kondolf and Curry, 1986). Along the Salinas River, base flow is maintained by releases from San Antonio and Nacimiento reservoirs, designed to recharge the alluvial water table from which local farms draw their water.

Groundwater levels have also dropped in the alluvial flat adjacent to the Sisquoc River, caused by instream gravel mining which lowered the river bed 40 feet in places.

Riparian vegetation in the Santa Cruz and Santa Lucia mountains is limited to narrow stream borders, and is similar to that on the forested coastal rivers of the North Coast region. Redwood is often present, such as along the San Lorenzo River. By contrast, valley areas in the Central Coast once supported large flood plain forests of deciduous riparian trees and shrubs, dominated by sycamore, willows, and Fremont and black cottonwood. Because of the long-time use of the area for grazing and agriculture, such valley riparian habitat is now scarce. Water regulation by upstream dams and ground water pumping also have impacted these riparian communities. Remaining patches of riparian habitat on the Salinas River and a few other localities in the Central Coast are important as some of the last known breeding areas of the Least Bell's Vireo, a state and federally listed endangered bird species (DFG, 1992a).

There are two types of natural fish fauna in the Central Coast. The larger Salinas/Pajaro River systems have species characteristic of the lowland habitats of the Sacramento-San Joaquin systems—such as Sacramento squawfish, Sacramento sucker and hitch—and a coastal fish community of anadromous species. Smaller rivers mostly have only anadromous species which can take advantage of seasonal high flows. Steelhead and Pacific lamprey are the most common anadromous fish on all the region's rivers, but have drastically diminished in numbers during the past decades.

Figure 60. Salinas River.

**Case Study: Salinas River—
An Agricultural River**

A few miles south of Soledad, the Salinas River drops in close to the hillside bank and runs deep and green. The water is warm too, for it has slipped twinkling over the yellow sands in the sunlight before reaching the narrow pool. On one side of the river the golden foothill slopes curve up to the strong and rocky Gabilan mountains, but on the valley side the water is lined with trees-willows fresh and green with every spring, carrying in their lower leaf junctures the debris of the

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winter's flooding; and sycamores with mottled, white, recumbent limbs and branches that arch over the pool. On the sandy bank under the trees the leaves lie deep and so crisp that a lizard makes a great skittering if he runs among them. Rabbits come out of the brush to sit on the sand in the evening, and the damp flats are covered with the night tracks of 'coons, and with the spread pads of dogs from the ranches, and with the split-wedge tracks of deer that come to drink in the dark. (John Steinbeck, *Of Mice and Men*, 1937.)

The Salinas River is the Central Coast region's largest river, flowing through the longest inter-mountain valley in the state. It originates in the mountains to the east of City of San Luis Obispo and flows 170 miles northward to Monterey Bay, largely paralleling U.S. Highway 101.

The Salinas has been called the "upside-down river" because it flows north and, for much of its length, underground (Fisher, 1945, referenced in U.S. National Park Service, 1992). It is one of the largest "submerged" rivers in the U.S. (California Coastal Commission, 1987), flowing through extremely porous substrates underlying the bed and flood plain.

Headwaters of the Salinas are dammed at Santa Margarita Reservoir to provide water for the City of San Luis Obispo. Coming out of the hills, the river meanders through valley lands around Atascadero and Paso Robles in San Luis Obispo County. In Monterey County, for the final half of its length, the river main stem passes through the Salinas Valley, one of the state's richest farming regions.

Near the county line, the Salinas receives waters from major tributary rivers, the Nacimiento and San Antonio, which are also dammed. The dams on the Nacimiento and San Antonio rivers were built and are operated by Monterey County water supply interests. They are used primarily for recharging groundwater in the Salinas Valley, where wells are the source of water for farms and urban use in the city of Salinas. Stored water is released from the dams to flow down the river for percolation into the ground.

The Salinas Valley in Monterey County is faced with a number of water problems including: widespread groundwater overdraft and inadequate

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water supply for recharge; seawater intrusion into aquifers near the coast caused by groundwater depletion; surface and ground water quality problems from nutrient enrichment and pesticides; and flooding. The Monterey County Water Resources Agency (MCWRA; formerly the Monterey County Flood Control and Water Conservation District) has embarked on a major planning effort to solve problems related to flood control, water supply and environmental protection. This program, the Salinas River Basin Water Resources Management Plan Study, involves the inventory of natural and socio-economic conditions; review of watershed, river and groundwater management; and study of water supply and demand (Source: various editions of the *Water Resources Quarterly*, Newsletter for the Salinas River Basin Water Resources Management Planning Project).

Although pesticides are widely used on farms in the Salinas Valley, current practices are not as significant a water quality problem as is residue from pesticides used in the past. Poisons which are now banned, such as Dieldrin and DDT, still persist in high concentrations in the soil and can enter the Salinas River through the natural processes of runoff and drainage, and through agricultural land practices. The Association of Monterey Bay Area Governments, with partial funding by USEPA, has undertaken a pilot project to assess the problem and recommend Best Management Practices to reduce pesticide migration from soil to river (Kleinfelder, Inc., 1992).

At the ocean, the Salinas River historically was blocked, except at unusually high flows, by a strip of coastal dunes and turned north to flow past Moss Landing into Elkhorn Slough. The extensive salt marshes in the area gave the Salinas River its name. Around the turn of the century, land near the coast was diked and drained for agriculture and a new mouth was created straight through the barrier dune system, leaving a only a narrow channel to Moss Landing called the Old Salinas River. However, the new "mouth" of the Salinas River is still frequently blocked at the dunes at low flows, creating a lagoon.

The Salinas Lagoon area is rich in fish and wildlife values including wetlands, dunes, riparian

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vegetation and estuarine aquatic habitats. The California Department of Parks and Recreation and the U.S. Fish and Wildlife Service both have land holdings in the lagoon and beach area. With high flows in winter, the dunes are breached, which opens the river mouth and drains the lagoon. Under certain conditions flows are high enough to cause the lagoon to back up and flood adjacent farm lands but not high enough to open the mouth.

The MCWRA has assembled the Salinas River Lagoon Task Force to address the special problems of lagoon water management for flood control and habitat protection and restoration. The group is made up of federal, state and local agencies, and other private parties and organizations. In 1993, the Salinas River Management and Enhancement Plan (prepared for the task force by a team of consultants) was released which recommends measures to address flooding and biotic resources.

In San Luis Obispo County, the upriver end of the Salinas River has long been used as a source of water for agriculture and pasture, and as an unofficial recreation site for hiking, horseback riding, and wildlife enjoyment. In recent years, the area's population has increased, leading to heavier and heavier use of the river. Trespass and vandalism problems are rampant, and local people are concerned about damage to habitats and property, and degradation of water supply and quality with increased development. Citizens have initiated a planning and problem-solving program, using the model of the Coordinated Resource Management and Planning (CRMP) process. Government agencies such as the County Parks Department and the Rivers and Trails Conservation Assistance Program of the National Park Service are assisting the effort (U.S. National Park Service, 1992). Comprehensive river planning in a community in transition from rural to more populated will be difficult, but it is important for all competing interests along the river.

Thus, the long Salinas River is finally the focus of comprehensive management in both counties through which it flows. In the future, the river will no longer be treated merely as a water supply or a flood threat, but as a renewable resource which needs to be

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managed for protection in perpetuity. Values of the river other than water supply—such as fish and wildlife habitat and public recreation—will be part of long-term management goals.

Table 8. Major Rivers in the Central Coast Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Arroyo Seco	40	385
Big Sur	21	70
Carmel	35	250
Cuyama	91	1,130
Estrella	55	800
Guadalupe	12	150
Huasna	25	115
Little Sur	12	45
Nacimiento	65	325
Pajaro	40	1,190
Salinas	180	4,160
San Antonio	60	310
San Benito	80	540
San Lorenzo	25	137
Santa Maria	20	1,740
Santa Ynez	70	845
Sisquoc	45	445

Kreissman, 1991.

Figure 61. Eastside/Great Basin Region.

Eastside/Great Basin Region

The Eastside/Great Basin region includes most of the California extent of the Great Basin (also called Basin and Range) Province, exclusive of the Mojave Desert. No waterways in this area drain to the sea; all dead-end in lakes or dry sinks.

During the Pleistocene epoch the Great Basin region of the United States was covered by lakes so vast they were more like inland seas. In the western part of the Great Basin, Lake Lahontan covered over 8,000 square miles. As the climate gradually dried into the modern regime, Lake Lahontan shrank, leaving a series of smaller lakes behind, including Honey Lake in California and Pyramid and Walker lakes in Nevada. These lakes are fed by rivers originating in the California mountains to the west (Minshall et al., 1989), such as the Truckee and Walker.

This region lies in the rain shadow of the Sierra-Cascade ranges and receives very little precipitation compared to the mountains to the west. The Sierra Nevada is an asymmetrical range, with a broad western slope and steep eastern slope, so rivers draining the eastern side have smaller drainage basins, relatively low flows and steep gradients. Eastside rivers are fed by high elevation snowmelt, originating in the steep eastern front of the mountains and flowing through the semiarid plateau and valley regions below. Runoff is greatest during snowmelt in May and June. Despite high precipitation on the range crest (e.g. 60 inches annually near Soda Springs), Susanville receives only 16 inches and Bishop only six inches.

Riparian tree and shrub vegetation is limited to narrow corridors along rivers in this harsh region. Even the oasis-like lower Owens River (below its gorge) in the Owens Valley, by most accounts, historically had relatively little riparian woodland and forest, but was primarily an area of extensive wet meadows and wetlands (Brothers, 1984).

The native fish fauna in this region, dominated by endemics, has been severely altered by habitat degradation and introductions of nonnative species and strains. The Lahontan Cutthroat trout was formerly wide-spread throughout much of the region, primarily inhabiting the Great Basin lakes and spawning up their tributary rivers including the Truckee, Carson and Walker. These fish were once so abundant they supported a commercial fishery in the area (Minshall et al., 1989). Because of dams, diversions and the introduction of other trout species, the Lahontan Cutthroat is now exceedingly rare and is a federal threatened species.

The Owens River has been isolated since Pleistocene time and unique fish species evolved, adapted to the difficult conditions of aquatic life in the arid environment. Native Owens Valley fish include the state and federal endangered Owens Tui Chub and

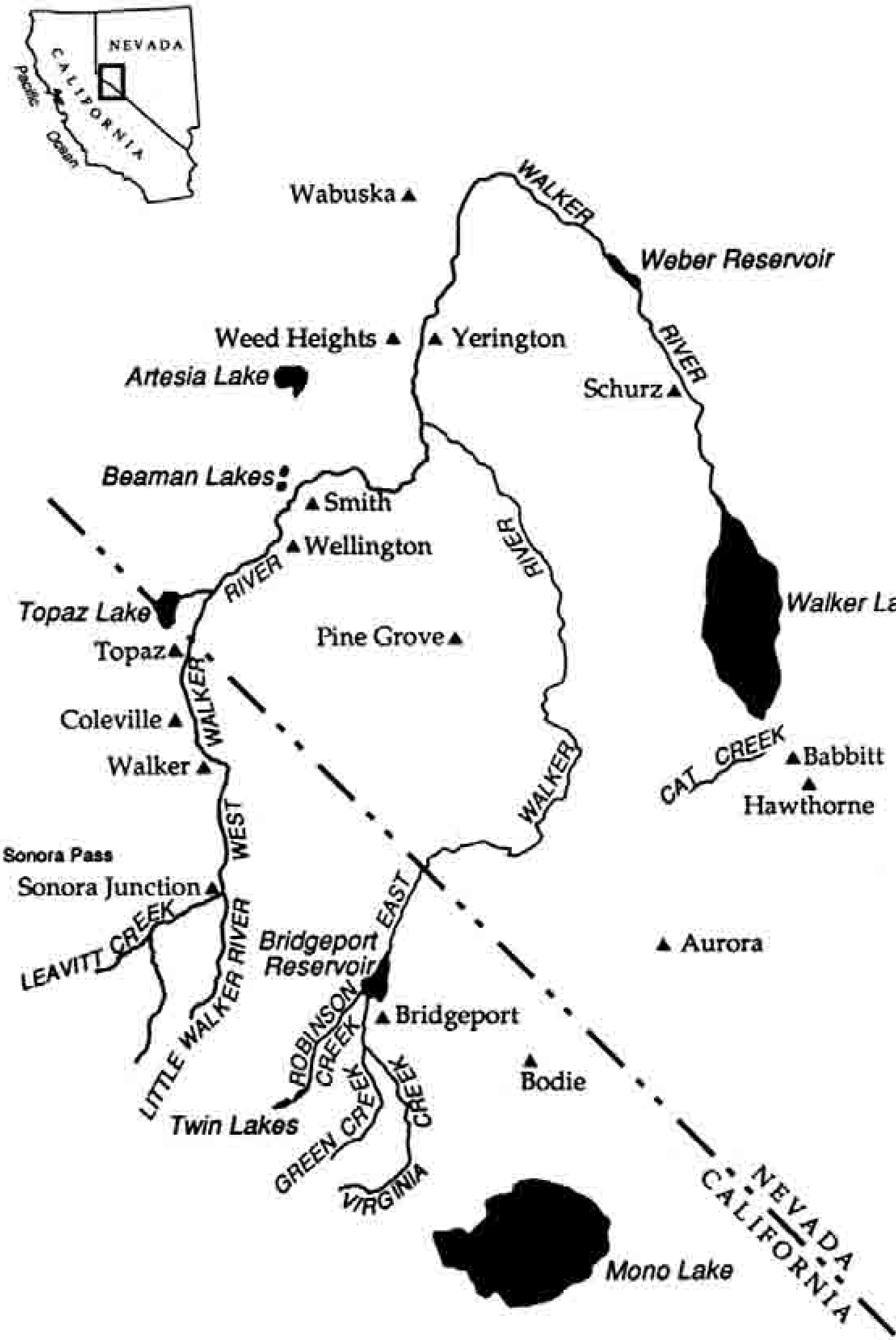

Figure 62. Walker River Watershed.

Owens Pupfish, and two California Species of Special Concern, the Owens Sucker and Owens Speckled Dace.

All of the rivers in this region have been dammed and diverted for agricultural or municipal water supply. The Truckee River, regulated by Lake Tahoe, is an important water source for Reno, Nevada and for agricultural interests in the region. As a result of diversions, its inflow into Pyramid Lake has been reduced and the lake level has fallen as evaporation has exceeded inflow.

The Owens River is probably the best known river in this region, because of the controversy over water use by the City of Los Angeles. In the gorge, the river had been diverted into penstocks which effectively dewatered the channel through the gorge, formerly a superb trout fishery. Although water eventually rejoined the channel for a short length in the upper valley, another diversion point diverts the flow again into an aqueduct for export to the City of Los Angeles (Figures 63 and 64). Below this diversion point, the river is essentially dry. The Owens River ends in Owens Lake. When Los Angeles diverted the river into its aqueduct, this once huge saline lake dried up, which is its current condition, except in wet years.

Figure 63. Owens River above Los Angeles Aqueduct.

Figure 64. Owens River below Los Angeles Aqueduct.

Such alterations in river flow, along with grazing and farming in the Owens Valley, have threatened the unique fish fauna and degraded riparian and wetland valley habitats. In addition to the direct diversion of the river, the groundwater is pumped within the valley for use in and out of the basin, which also degrades aquatic habitats. Currently, after long legal battles, the gorge fishery is being restored and plans are being formulated to restore the lower Owens River.

Case Study: Walker River

The Walker River has its headwaters in the crest of the Sierra Nevada. It runs clear and cold in the mountains down to flatter valleys to the east, ending in

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Walker Lake in Nevada. In the lowlands it becomes slower, meandering, and heavily laden with dissolved and suspended solids. The Walker is actually two forks, joining together far down its length inside Nevada. Within California, the Walker remains separate in the East Walker and West Walker rivers.

Figure 65. Walker River.

When European-American settlers first came to the area in the 1700s, the Walker River system (as well as the Carson, Truckee and other eastside rivers), supported huge spawning runs of Lahontan cutthroat trout. Up to the early 1800s a thriving commercial fishery existed in the region. With the mining boom in the area after 1850, dams and diversions begin to severely reduce cutthroat populations. On the Walker, spawning runs still survived into the 1920s and 1930s in the Antelope Valley on the West Walker and in Bridgeport Valley on the East Walker (Minshall et al., 1989).

The West Walker is larger than the East Walker, but neither is very large in total runoff. They are similar in size to most rivers in the South Coast region of California, but flow peaks are in May and June, rather than winter or early spring. Despite the small size of the Walker system, it has been the subject of many legal battles for rights to its water in this arid region. The following historical review is from the *Walker River Atlas* (DWR, 1992).

When farmers and ranchers settled the Walker River valleys in eastern California and western Nevada,

Continued on next page.

they turned to the only decent source of water around, the river itself. At first farmers and ranchers settled close to the river for a riparian water supply. As agriculture expanded, primitive irrigation systems were developed including small seasonal dams and ditch systems. With water in short supply, a number of conflicts soon arose over water rights on the Walker, in large part between ranchers in California and Nevada. Litigation led to a federal court decree in 1919 specifying water rights in the area. In response to the litigation and decree, farmers in Nevada established the Walker River Irrigation District, to insure an adequate water supply for themselves. The Nevada based district went into California and built two reservoirs in the early 1920s, one at Topaz Reservoir on the West Walker, and one at Bridgeport on the East Walker. Shortly thereafter another lawsuit led to a new federal decree (Decree C-125) on water rights in California and Nevada, which is in existence today.

After World War II, interest grew in further developing the Walker system for additional supply. New reservoir sites were studied, including two areas on the West Walker near Sonora Junction. These were not constructed due to cost.

In recent decades, other uses of the Walker have gained importance, namely recreation and environmental protection. Fishing is quite popular on the two branches of the Walker in California, especially in the canyon paralleling Highway 395 in the West Walker and below Bridgeport Reservoir on the East Walker. Although the native Lahontan Cutthroat is no longer present, the California Department of Fish and Game actively manages both rivers for hatchery raised rainbow, brook and brown trout. In 1989 part of the West Walker was included in the California Wild and Scenic River system, precluding building the once-proposed additional reservoirs.

Today, the major conflict is not between ranchers over water rights, but between California fisheries and Nevada irrigators. In the late 1980s, the Walker River Irrigation District drained Bridgeport Reservoir to supply its Nevada farms and ranches. The fish in the reservoir died, and the release of an enormous amount of mud as the stream cut into the lake bottom resulted in a massive fish kill in the East Walker below the dam.

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Both areas had been popular for fishing. In 1988 California Trout, Inc., a fishing and environmental organization, filed a complaint with the State Water Resources Control Board. After an attempt at negotiation between the district and the California Department of Fish and Game, the SWRCB went ahead with a full investigation and water rights hearing.

Meanwhile, Mono County achieved convictions on criminal misdemeanor charges against the district for violation of California Fish and Game Code violations. Later, in 1990, the SWRCB completed its hearing process and amended the district's water right permit to protect the fishery in the reservoir pool and the river downstream. The district has now filed suit against the SWRCB, challenging its authority, on the basis that the federal Decree C-125 had already determined water rights on the river.

Within the state of Nevada, the diversion of Walker River water has its own environmental conflict. Flow reductions in the Walker have been depriving Walker Lake of its inflow, resulting in the lowering of the lake's water elevation and an increase in salinity. The Lahontan Cutthroat, now maintained by hatchery propagation, is at extreme risk of survival in the lake's salty waters. This is, of course, another example of a pervasive environmental problem occurring throughout the eastside region; Pyramid Lake, Mono Lake and Owens Lake are also drying up or have dried up due to upstream diversions.

Table 9. Major Rivers in the Eastside/Great Basin Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Carson	46	280
Owens	120	1,965
Susan	59	185
Truckee	60	930
Walker	47	360

Kreissman, 1991.

Figure 66. South Coast Region.

South Coast Region

The South Coast region includes the watersheds of coastal streams from the Ventura River south to the Tijuana River estuary near the Mexican border. This region juxtaposes short but rugged mountain ranges with intensely developed plains and valleys. Urbanization and agricultural land use on what used to be river flood plains has led to widespread damming and channelization of the region's natural waterways.

In the north part of the region, the Transverse Ranges run east-west, as does one of the principle drainages, the long Santa Clara River, which enters the ocean between Ventura and Oxnard. Further south and east lies the urbanized Los Angeles plain which is crossed by the highly regulated Los Angeles, San Gabriel and Santa Ana rivers. Old photographs show that these rivers were already channelized by the late 1920s (Faber et al., 1989). In San Diego County, the north-south trending Peninsular Ranges are drained by a series of short rivers, including the San Luis Rey, Santa Margarita and San Diego rivers. These rivers cut into a broad mesa, or coastal terrace, as they flow to the sea.

Precipitation is low overall in the region, with 14 inches at Santa Barbara and 10 inches at San Diego. However, rain usually falls in intense cyclonic storms or local convective storms. As a result, the rivers have highly seasonal flow and enormous year-to-year variations. These rivers can be dry (or nearly so) most of the year, except for huge floods that can cause sudden rises in river stage. Most South Coast rivers are perennial in their mountainous headwaters, but intermittent or ephemeral, that is, they flow only in direct response to intense rainfall and usually dry up within days or weeks, downstream in the alluvial basins and coastal terraces. This is especially true now because of extensive groundwater withdrawals from the alluvial basins.

The broad natural channels of sand and gravel characteristic of these rivers reflect not only the extreme variation in discharge, but also their high sediment loads, especially the load of sand and gravel. Debris flows are frequent occurrences in the mountainous headwaters of these river systems, posing a chronic risk and management problem to the heavily urbanized canyons and foothills of Los Angeles. Sediment transport is now highly regulated by reservoirs, debris basins and flood control channels. Because of the trapping of the natural sediment load, the natural delivery of sand to beaches has been reduced, with the result that most of the region's beaches are now experiencing erosion problems.

The impact of development on southern region rivers has been substantial. Clearing for urbanization and agriculture destroyed and degraded riparian and aquatic habitats as did the flood control and water supply projects which accompanied such development. Table 10 illustrates the degree to which controls have been placed on seven major river systems in the South Coast area.

Table 10. Major Southern California River Systems Controlled by Dams and Channelization, as of Early 1980s.

River System	% of Basin Controlled By Dams	Miles Inventoried	Channel Condition % Natural	Channel Condition %Channelized
Ventura	42	90	70	30
Santa Clara	37	320	49	41
Los Angeles	40	235	12	89
San Gabriel	84	106	42	59
Santa Ana	90	278	36	64
San Luis Rey	37	141	60	39
San Diego	61	141	69	31

* Includes main river channel and major tributaries.

Faber et al., 1989

Other current threats to river corridors in the South Coast include sand and gravel mining, off-highway vehicle damage, illegal dumping, pollution, and introduced plant and animal species. Rivers that are not completely channelized still remain and offer good potential for restoration, such as the San Luis Rey and Santa Margarita rivers in San Diego County (Faber et al., 1989).

Natural riparian vegetation along river flood plains in the South Coast is dominated by many species common to river valleys throughout the state, including Fremont and black cottonwood, willows, sycamore and white alder. Historically such vegetation was found along many rivers and streams of the area, but was probably less extensive than in other parts of the state due to the more arid conditions. Currently, less than five percent of the natural riparian vegetation remains in the south coast (Faber et al., 1989).

In southern California mountain canyons, several tree species which are found normally upland in the northern part of the state, become restricted to riparian environments—including coast live oak, canyon live oak and California bay, which grow together with the more typically riparian white alder, cottonwoods and sycamore. Canyons are subject to less urban and agricultural development than valley flood plains, and thus have more natural riparian vegetation remaining. However, such areas are often subject to heavy recreational use.

Alluvial outwash fans on rivers and streams flowing out of the San Gabriel, San Bernardino and San Jacinto mountains support a unique type of scrubby vegetation (Hanes et al., 1989). Alluvial fan scrub is composed of species adapted for the extreme conditions of

Figure 67. Channelized Santa Ana River Mouth, 1927.

Source: Whittier College Geology Department
Fairchild Collection, photo date 1927.

mostly dry sandy and gravelly soils subject to infrequent but intense floods. Scale-broom, California buckwheat and mulefat are some of the common species. Such alluvial fan scrub once covered much of the Los Angeles Basin (Faber et al., 1989). Flood plain development and other impacts have almost completely eliminated this plant community (Hanes et al., 1989). Two alluvial fan scrub plants are state and federally listed endangered species—the Santa Ana River Woolly-star and the Slender-horned Spineflower.

Where they met the ocean, many rivers and streams in the South Coast area formed large estuarine ecosystems. Flood control projects and shore zone development have now drastically reduced and fragmented most southern California estuarine systems.

The Least Bell's Vireo, a state and federally endangered bird species, is dependent upon willow-dominated riparian vegetation for suitable nesting sites. This bird has declined more drastically than other passerine (perching songbird) species in California (US Fish and Wildlife Service, 1986.) Habitat loss throughout the state has limited the species to a few nesting areas, with southern California rivers some of the few remaining important sites. Continuing habitat loss and nest predation by the Brown-headed Cowbird critically threaten the Least Bell's Vireo.

The native fish fauna was never very diverse in the South Coast region, but all species have suffered significant declines. Most native species are so limited they are now species of concern, including the Santa Ana Sucker, the Santa Ana Speckled Dace, and the Arroyo Chub. The Unarmored Threespine Stickleback, a state and federally endangered fish species, is restricted to the upper Santa Clara River system and one other isolated transplanted population in San Diego County.

Remarkably, numerous South Coastal rivers and streams, all the way through to San Diego County, once supported steelhead runs of 5,000 to 20,000 adults. Now, all runs are lost except remnant populations in the Ventura and Santa Clara river systems and Malibu Creek in the Santa Monica Mountains (Nehlsen et al., 1991). Sespe Creek, a tributary of the Santa Clara River, contains almost all of the suitable steelhead spawning habitat left in the system (Keep the Sespe Wild Committee, 1992). Efforts are underway by public interest environmental groups and government agencies to restore the steelhead populations in southern California.

Case Study: Santa Ana River— Flood plain Development

The Santa Ana River basin is the largest in the South Coast region, with a watershed of 2,400 square miles. The Santa Ana River is the principal drainage of the San Bernardino Mountains. The large watershed size and high elevation of its headwaters region caused the Santa Ana River in its natural state to flood with tremendous force, albeit infrequently. In the flood of record in 1938, the Santa Ana River carried over 40,000 cfs as it emerged from the San Bernardino Mountains.

In the San Bernardino Mountains, the Santa Ana River and tributaries support typical riparian plant communities of cottonwood, willows, white alder and sycamore (Faber et al., 1989). Where the river system comes out of the mountains northeast of Redlands, it forms a wide flood plain wash, with unique alluvial fan scrub vegetation. Flowing westward over the plain past the City of Riverside, the river goes through the Prado Basin, the Santa Ana River Canyon in the Santa Ana Mountains, and then to the sea. Lowland riparian forests and woodlands still remain along the Santa Ana River where it has not yet been channelized (Hanes, 1984). Where the river historically met the ocean, in a location in present-day Orange County, it once flowed through a marsh thousands of acres in size, winding south into lower Newport Bay. Now the lower river

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runs straight into the ocean in a concrete channel, with only fragments of marshland left in the area (California Coastal Commission, 1987). The lower 23 miles of the Santa Ana River was channelized to the Pacific by 1927 (Faber et al., 1989) . Prado Dam was constructed on the river in the Santa Ana Mountains in 1941, flooding the Prado Basin with a flood control reservoir.

Urbanization, of course, is widespread in the area, including within the natural flood plain of the Santa Ana River. The flood protection intended by Prado Dam and previous channelization is now judged by the Army Corps of Engineers to be inadequate to protect the coastal plain of Orange County. In part, this was due to increased run-off in the watershed due to urbanization, and to the silting in of Prado Reservoir, which decreased its flood storage capacity. In addition, the now-developed areas of Riverside and San Bernardino counties in the river flood plain above the Prado Basin are also considered vulnerable to flood hazard. The Corps estimates that billions of dollars of property values and millions of people are at risk, stating "[t]he Santa Ana River is currently the worst flood threat west of the Mississippi River" (U.S. Army Corps of Engineers, 1989).

While the Santa Ana River may pose a serious flood threat to humans, the flood control works the Corps has planned to constrain the river and its tributaries are an equally serious threat to ecological values in the area. New upstream dams and levees east of Redlands will destroy aquatic and riparian habitats, including alluvial fan scrub.

Currently the Prado Basin contains the largest riparian woodland in southern California (Faber et al., 1989). When Prado Dam was built, it resulted in the destruction of significant amounts of riparian habitat. However, new riparian habitat has become established in the basin due to the reservoir, and it is possible that there is actually more habitat now then there was historically in the Prado Basin (U.S. Fish and Wildlife Service, 1986). However, it should be noted that channelization below the dam resulted in the loss of extensive amounts of riparian habitat.

The endangered Least Bell's Vireo is found in the Santa Ana River system, including the Prado Basin and below the dam. Part of the Corps' proposed flood control retrofit is to enlarge Prado Dam, which could

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endanger the Vireo, as well as other wildlife.

Ironically, as the pressure to control the river grows, so has an appreciation of the natural values of the river. The Santa Ana River Trail is a multiagency project to create a continuous trail from the San Bernardino National Forest to the Pacific Ocean. (Figure 68).

Figure 68. Santa Ana River, Restored Segment.

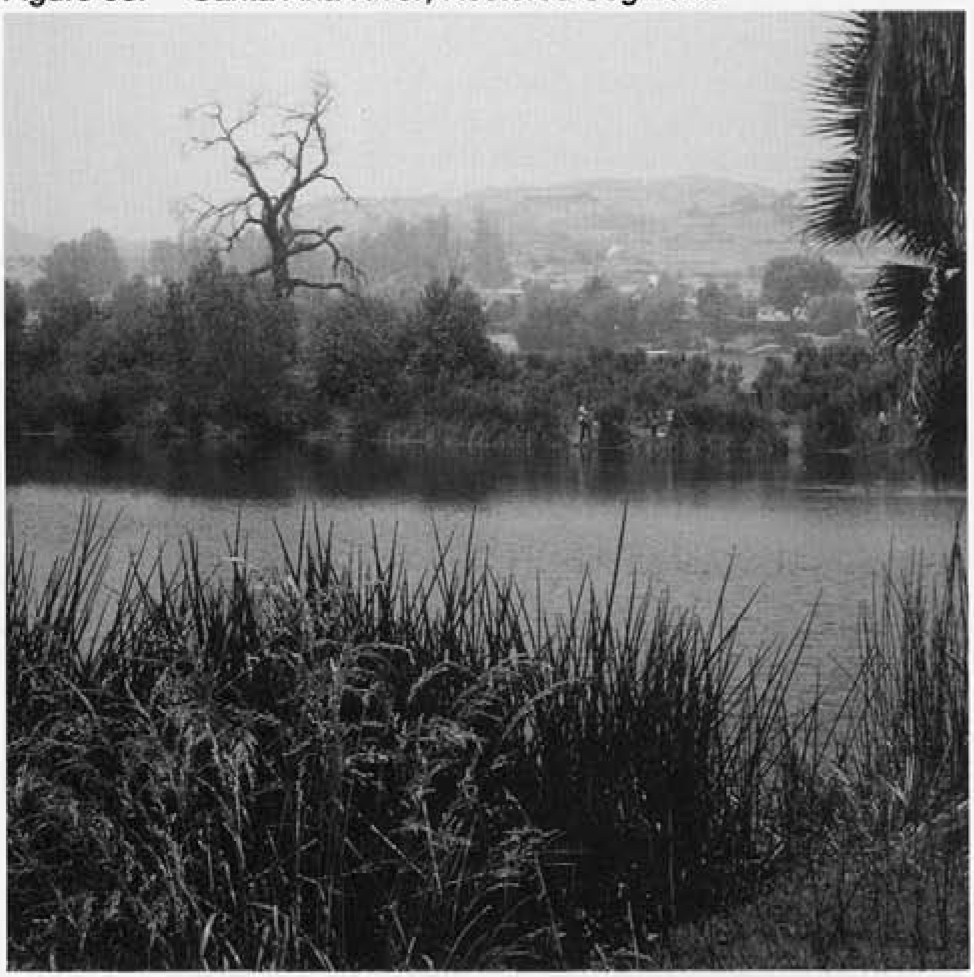

Table 11. Major Rivers in the South Coast Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Los Angeles	97	830
Otay	25	135
Rio Hondo	20	125
San Diego	45	439
San Dieguito	11?	300
San Gabriel	59	350
San Jacinto	38	725
San Luis Rey	51	575
Santa Ana	93	1,700
Santa Clara	75	1,616
Santa Margarita	11?	740
Sweetwater	11?	190
Ventura	33	190

Kreissman, 1991.

Figure 69. Desert Region.

Desert Region

The Desert region of California encompasses the Mojave and Colorado (Sonoran) desert areas. This combines the southern part of the Lahontan hydrologic basin with the Colorado River basin.

Rainfall in the desert is low and evaporation high. Barstow receives just over four inches annually. Natural rivers in this region are few and are mostly ephemeral. The Amargosa and Mojave rivers are the two purely "desert" rivers within the state. Their channel flood plains are dry washes, except for points where high ground water tables bring water to the surface and support distinctive riparian and aquatic communities.

The Amargosa River arises in mountains in Nevada, flows south into California, then loops north to Death Valley, although surface water rarely reaches all the way to this end point. The Amargosa River is dry for most of the year, except for isolated flash floods.

The few places with surface water, fed by springs, along the Amargosa are "ecological islands" and support uncommon flora and fauna, such as in the Amargosa Canyon in San Bernardino County (Williams, J. et al., 1984). At the California-Nevada border, the Amargosa River passes through Ash Meadows, an area of spring-fed wetlands which has more endemic plant and animal species than any other area in the United States (Williams, C., 1984). Amargosa River aquatic and wetland biotic resources are threatened by the invasion of nonnative competitors and predators, and by declines in surface water quantity and quality from human activities.

Case Study: Colorado River

The most exceptional river in the desert region is the Colorado River, which drains 242,000 square miles of the Rocky Mountains and Colorado Plateau. Seven states share the length of the river's 1,700 miles as it falls nearly two vertical miles. The Colorado River passes California, forming the state's border with Arizona, then flows into Mexico and the Sea of Cortez (Gulf of California).

With an unimpaired average annual flow of 15 million acre-feet, the Colorado River in its natural state is between the Klamath and Sacramento rivers in size. The Colorado once carried immense silt loads, at concentrations ten times greater than the Nile (California Water Atlas, 1979). Natural flows varied widely between years, including occasional massive spring and summer

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floods with heavy sediment deposition.

The lower Colorado River (below Hoover Dam) was formerly an actively meandering river system, bordered by extensive riparian forests and wetlands. It flowed into the Sea of Cortez through its enormous migrating delta system below Yuma. The river naturally flooded its bottomlands with large silt-laden flood pulses. The New and Alamo rivers in the Imperial Valley were in fact old flood channels of the Colorado River conveying overflow northward into the Salton Sink from Mexico. At the turn of the century, an attempt was made at diverting irrigation water from the Colorado River to the Imperial Valley via the Alamo River and various canals. Massive spring floods in 1905 broke through canal levees, sending the whole Colorado River north for a while, forming what is now the Salton Sea (California Water Atlas, 1979).

The lower Colorado ecosystem was a rich and diverse area of river channels, sloughs and small back channels, marshes, arrowweed and willow scrub lands, cottonwood and willow flood plain forests, and mesquite bosques. There were at least 5,000 acres of cottonwood communities along the lower Colorado in the 1600s (Ohmart et al., 1977). The fish fauna was small but unique, including Bonytail, Colorado Squaw-fish and Razorback Sucker, which were all probably quite abundant (Minckley and Brown, 1982). In addition, Desert Pupfish were found in pools and marsh channels in the backwaters of the river (Moyle, 1976).

Today, it is hard to imagine a river with more alterations to its natural system and more conflict over its waters than the Colorado. Its silt-laden floods are now almost completely tamed by a sequence of massive reservoirs upstream, including Lake Mead (Hoover Dam) and Lake Powell (Glen Canyon Dam). The lower river is nearly completely artificial, with channel cuts, levees, and over a half dozen smaller impoundments from Needles to Yuma. Essentially all of the flow of the Colorado is appropriated for consumption, divided among seven states and Mexico under the Colorado River Compact. California takes by far the largest share of water from the Colorado, which supplies more than one-half the water used in Southern California.

Spanish explorers and later Anglo-American

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explorers and settlers to the lower Colorado began a process of impacts to the riparian and other habitats which has resulted in the near extirpation of native communities on the river. First, riparian forests were cut for fuelwood, and land cleared for agriculture. The modern dams and channelization works for flood control followed settlement, as did water diversions for irrigation and eventually for water supply for southern California. Tamarisk, or salt cedar, was introduced shortly after turn of the century and has spread vigorously throughout the bottomlands. The drastic changes in annual flow patterns following the closure of Hoover Dam has permitted Tamarisk to compete successfully for remaining groundwater in the former flood plain. Tamarisk provides little habitat for the local wildlife species, and is somewhat more water-using than indigenous vegetation.

The formerly extensive riparian habitat of this system has been reduced to a fragment of its original size. Because flow no longer varies in a natural way, riparian vegetation succession has been arrested, precluding natural reestablishment of riparian forests and woodlands. By the 1970s only a little over one-half the cottonwood-willow riparian forest remained (Ohmart et al., 1977). High water in 1983 and 1986 has all but eliminated most cottonwood-willow habitat (Laymon and Halterman, 1989). Today only a few isolated, mostly degraded willow and cottonwood stands can be found.

With such a severe loss of riparian, marsh and aquatic habitats, it is no surprise that the fish and wildlife species dependent upon them also have declined. The Colorado River has more species unique to it that are at critical risk of extinction than any other river in California. For example, along the entire lower Colorado, recent surveys have observed only a few successful breeding pairs of the Western Yellow-billed Cuckoo (Laymon and Halterman, 1989) and Gila Woodpecker (DFG, 1992). The Desert Pupfish and Colorado Squawfish no longer exist naturally in the lower Colorado and the Bonytail and Razorback Sucker are on the verge of extirpation.

These environmental problems are being addressed by several federal and state agencies with

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jurisdiction and interests in the Colorado river. According to a 1986 Bureau of Land Management jurisdiction map, of the 529 miles from Davis dam down to Yuma, there are only about 40 river miles of private riparian land on the California side, and 35 river miles of private land on both sides. Indian reservations, National Wildlife Refuges, Bureau of Reclamation (BOR) land and BLM and Arizona state lands include or at least abut the Colorado. The following identifies agencies' efforts to coordinate river management:

- The BOR, in concert with US Fish and Wildlife Service (USFWS), has inventoried environmental problems along the Lower Colorado and is beginning to revegetate a few places. Some modest adjustments of its water-diversion and -regulation functions have been made or agreed to. However, the old water contracts were based on wetter than normal years, so flows have seldom exceeded the amounts committed. Thus, there is not much hope for renegotiating the contracts with the seven states and Mexico to decrease their water entitlements for the benefit of the fishery or habitat uses.
- The USFWS operates the Lake Havasu, Cibola and Imperial National Wildlife refuges on the Lower Colorado. Their primary concerns in this area are to manage the refuges, to identify and map wetlands, and to ameliorate recreation's impact on wetlands and endangered species.
- The Fort Mojave, Chemehuevi, Colorado River and Fort Yuma Indian reservations in general operate as independent "nations." They have their own interests to pursue, including the concessioning of recreational development proposals. The tribes need not do environmental reporting for such projects, and are subject only to a limited range of regulatory requirements such as Section 404 of the Clean Water Act, Section 106 of the National Historic Preservation Act (re Cultural Resources), and the Endangered Species Act.
- BLM riparian lands in this desert terrain are managed primarily for recreational use. The primary users are southern Californians from Orange and Los Angeles counties. By agreement with the California State BLM Office, the Yuma

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District office also manages California BLM lands in the river valley. Providing river access facilities (launching ramps, day use and overnight camps, and marina concessions operating on BLM land) forms a major policy component of the district's responsibilities. However, user statistics have been only casually collected until recently. BLM is currently seeking a more active role in river habitat maintenance and improvement.

- Arizona State Lands Department lands along the river are managed in a similar manner as BLM for enabling and enhancing public (primarily recreational) use, and maintaining environmental values where these are not mutually incompatible.
- The Arizona State Parks Department has begun planning (in cooperation with Arizona Game and Fish and U.S. Fish & Wildlife Service) for enhancement of Arizona wetlands, the Colorado River included. Its statewide Rivers, Streams and Wetlands Study (1989) resulted in creation of a Governor's Riparian Habitat Task Force to define, classify and identify riparian areas' quality and needs. This program has resulted in a major Wetlands Inventory Database. State legislation also ensued, creating the Arizona Heritage Fund, in which $20 million a year from lottery receipts are designated for parks, trails, natural area acquisition, historic and archaeological preservation, and education. In addition, by a Governor's Executive Order, Arizona state government now has an official Riparian Protection Policy statement to guide its decisions and actions affecting wetlands.
- The California Department of Fish and Game and the Arizona Game and Fish Department have similar missions and methods, except the absence of a comparable environmental review process (CEQA) in Arizona for private projects. The National Environmental Policy Act (NEPA) and Clean Water Act Section 404 allow review and comment on federal projects on the Arizona side, however, and most of the riparian land there is federally owned.
- The California State Lands Commission's (SLCs) interest in the Colorado has been primarily to identify its last natural bed and to lease or exchange

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these lands to adjacent owners (principally farmers) for purposes of the Kapiloff Land Bank. The land bank process is invoked to benefit the trust for commerce, navigation and fisheries which characterizes the natural navigable waterways of California. Through the land bank process, the commission receives land which can be used for riparian habitat, recreational, use or access, or other environmental value, in exchange for releasing all of its title to the original bed of the river. These transactions usually occur where oxbows or berm areas are left high and dry by past diking or rechanneling of the river. Thus, they usually take place in sediment-deposit areas of flat valleys, rather than in steeper sediment-cutting river reaches. On the Colorado, that means generally from the Palo Verde Valley around Blythe, California downstream to its mouth at the Gulf of Mexico.

These programs demonstrate success in effective coordination. Agencies and private groups with interests in restoring resources of the river are agreeing to do so in "bite-sized" pilot or demonstration project.

Figure 70. Recreation on the Colorado River.

Table 12. Major Rivers in the Desert Region.

River	Length (mi.)	Watershed Area (sq. mi.)
Alamo	52	695
Amargosa	198	3,090
Colorado	230	3,950
Mojave	100	2,120
New	60	1,000
San Gregorio	30	155
Whitewater	25	1,500

Kreissman, 1991.

Table 13. Common or Indicator Riparian Plants of California.

Scientific name	Common name
Abies grandis	Grand Fir
Acer circinatum	Vine Maple
Acer macrophyllum	Big-leaf Maple
Acer negundo var. californicum	Box Elder
Aesculus californica	Buckeye
Ailanthus altissima (Intro.)	Tree-of-heaven
Alnus rhombifolia	White Alder
Alnus rubra	Red Alder
Alnus incana ssp. *tenuifolia*	Mountain Alder
Artemisia douglasiana	Mugwort
Aristolochia californica	Dutchman's Pipevine
Arundo donax (Intro.)	False-bamboo
Baccharis salicifolia	Mule Fat, Seep-willow
Betula occidentalis	Water Birch
Cephalanthus occidentalis var. *californicus*	Buttonbush, Button-willow
Clematis ligustifolia	Virgin's Bower
Cornus glabrata	Brown Dogwood
Cornus sericea ssp.	American Dogwood
Cortaderia jubata	Jubata (Pampas) Grass
Eichornia crassipes (Intro.)	Water Hyacinth
Equisetum spp.	Horsetail
Eriogonum fasciculatum var.	California buckwheat
Ficus carica (Intro.)	Common Fig
Fraxinus latifolia	Oregon Ash
Fraxinus velutina	Velvet Ash
Juglans californica var. *hindsii*	Northern California Black Walnut
Juglans nigra (Intro.)	Eastern Black Walnut
Lepidospartum squamatum	Scale-broom
Leymus triticoides	Creeping Wildrye
Phragmites australis	Common Reed
Picea sitchensis	Sitka Spruce
Pinus contorta ssp. *murrayana*	Lodgepole Pine
Platanus racemosa	Western Sycamore
Pluchea sericea	Arrow Weed
Populus fremontii	Fremont Cottonwood
Populus balsamifera ssp. *trichocarpa*	Black Cottonwood
Populus tremuloides	Aspen
Prosopis glandulosa var. *torreyana*	Honey Mesquite
Prosopis pubescens	Screw-bean Mesquite
Quercus agrifolia	Coast Live Oak
Quercus chrysolepis	Canyon Live Oak
Quercus kellogii	Black Oak
Quercus lobata	Valley Oak
Quercus wislizenii var. *wislizenii*	Interior Live Oak
Rubus procerus (Intro.); *R. ursinus*	Blackberries
Salix exigua	Sandbar Willow; Narrowleaf Willow
Salix geyeriana	Geyer's Willow
Salix goodingii	Gooding's Black Willow
Salix hookeriana	Coastal Willow
Salix laevigata	Red Willow
Salix lasiolepis	Arroyo Willow
Salix lucida ssp. *lasiandra*	Yellow Tree Willow
Salix lutea	Yellow Willow
Salix scouleriana	Scouler's Willow
Sambucus mexicana	Blue Elderberry
Sambucus racemosa var. *racemosa*	Red Elderberry
Sequoia sempervirens	Coast Redwood
Shepherdia argentea	Buffalo Berry
Tamarix parviflora; T. ramosissima	Salt Cedar, Tamarisk
Toxicodendron diversilobum	Poison Oak
Typha spp.	Cattails
Umbellularia californica	California Bay
Vitis californica	Wild Grape
Vitis girdiana	Desert Wild Grape

Table 14. Common or Indicator Animals of California.

	Distribution by Region +
Amphibians	
Northwestern Salamander *Ambystoma gracile*	NC
Western Toad *Bufo boreas*	NC,CV,Mo,CC,ES,SC
Pacific Giant Salamander *Dicamptodon ensatus*	NC
California Treefrog *Hyla cadaverina*	NC
Pacific Treefrog *Hyla regilla*	NC,CV,Mo,CC,ES,SC
Bullfrog *Rana catesbeiana*	NC,CV,Mo,CC,ES,SC,D
Rough-skinned Newt *Taricha granulosa*	Mo
California Newt *Taricha torosa**	CV,Mo
Reptiles	
Rubber Boa *Charina bottae*	NC,CV,Mo,CC
Common Kingsnake *Lampropeltis getulus* NC,CV,Mo,CC,ES,SC,D	
Western Aquatic Garter Snake *Thamnophis couchi*	NC,VC,Mo,CC,SC
Western Terrestrial Garter Snake *Thamnophis elegans*	NC,CV,CC
Common Garter Snake *Thamnophis sirtalis*	NC,CV,Mo,CC,SC
Birds	
Spotted Sandpiper *Actitis macularia*	NC,CV,Mo,CC,ES,SC,D
Red-winged Blackbird *Agelaius phoeniceus*	NC,CV,Mo,CC,ES,SC,D
Wood Duck *Aix sponsa*	NC,CV,CC,SC
Scrub Jay *Aphelocoma coerulescens*	NC,CV,Mo,CC,ES,SC
Black-chinned Hummingbird *Archilochus alexandri*	CV,Mo,CC,ES,SC,D
Cedar Waxwing *Bombycilla cedrorum*	NC,CV,Mo,CC,ES,SC,D
American Bittern *Botaurus lentiginosus*	NC,CV,Mo,CC,ES,SC,D
Great Horned Owl *Bubo virginianus*	NC,CV,Mo,CC,ES,SC,D
Red-tailed Hawk *Buteo jamaicensis*	NC,CV,Mo,CC,ES,SC,D
Rough-legged Hawk *Buteo lagopus*	NC,CV,Mo,CC,ES,SC,D
Red-shouldered Hawk *Buteo lineatus*	NC,CV,CC,SC
Green-backed Heron *Butoroides striatus*	NC,CV,CC,SC,D
California Quail *Callipepla californica*	NC,CV,Mo,CC,ES,SC,D
Lesser Goldfinch *Carduelis psaltria*	NC,CV,Mo,CC,ES,SC,D
American Goldfinch *Carduelis tristis*	NC,CV,Mo,CC,ES,SC,D
House Finch *Carpodacus mexicanus*	NC,CV,Mo,CC,ES,SC,D
Purple Finch *Carpodacus purpureus*	NC,CV,Mo,CC,ES,SC
Swainson's Thrush *Catharus ustulatus*	NC,CV,Mo,CC,ES,SC
Belted Kingfisher *Ceryle alcyon*	NC,CV,Mo,CC,ES,SC,D
Killdeer *Charadrius vociferus*	NC,CV,Mo,CC,ES,SC,D
American Dipper *Cinclus mexicanus*	NC,CV,Mo,CC,ES,SC
Northern Flicker *Colaptes auratus**	NC,CV,Mo,CC,ES,SC,D
Western Wood-Peewee *Contopus sordidulus*	NC,CV,Mo,CC,ES,SC
American Crow *Corvus brachyrhynchos*	NC,CV,Mo,CC,ES,SC,D
Common Raven *Corvus corax*	NC,CV,Mo,CC,ES,SC,D
Stellar's Jay *Cyanocitta stelleri*	NC,CV,Mo,CC,ES,SC
Pacific-slope Flycatcher *Empidonax difficilis*	NC,CV,CC,SC
Brewer's Blackbird *Euphagus cyanocephalus*	NC,CV,Mo,CC,ES,SC,D
American Kestrel *Falco sparverius*	NC,CV,Mo,CC,ES,SC,D
Common Yellowthroat *Geothlypis trichas*	NC,CV,Mo,CC,ES,SC,D

Continued on next page.

Table 14. Continued.

	Distribution by Region +
Northern Pigmy Owl *Glaucidium gnoma*	NC,CV
Blue Grosbeak *Guiraca caerulea*	CV,CC,ES,SC,D
Cliff Swallow *Hirundo pyrrhonota*	NC,CV,Mo,CC,ES,SC,D
Hooded Oriole *Icterus cucullatus*	NC,CV,CC,ES,SC,D
Northern Oriole *Icterus galbula*	NC,CV,Mo,CC,ES,SC,D
Dark-eyed Junco *Junco hyemalis*	NC,CV,Mo,CC,ES,SC,D
Hooded Merganser *Lophodytes cucullatus*	NC,CV,Mo,CC,SC,D
Acorn Woodpecker *Melanerpes formicivorus*	NC,CV,Mo,CC,SC
Song Sparrow *Melospiza melodia*	NC,CV,Mo,CC,ES,SC,D
Lincoln's Sparrow *Melospiza lincolnii*	NC,CV,Mo,CC,ES,SC,D
Common Merganser *Mergus merganser*	NC,CV,Mo,CC,ES,SC,D
Northern Mockingbird *Mimus polyglottos*	NC,CV,Mo,CC,ES,SC,D
Brownheaded Cowbird *Molothrus ater*	NC,CV,Mo,CC,ES,SC,D
Ash-throated Flycatcher *Myiarchus cinerascens*	NC,CV,Mo,CC,ES,SC,D
Brown-crested Flycatcher *Myiarchus tyrannulus*	D
Western Screech-owl *Otus kennicottii*	NC,CV,Mo,CC,ES,SC,D
Plain Titmouse *Parus inornatus*	NC,CV,Mo,CC,ES,SC,D
Fox Sparrow *Passerella iliaca*	NC,CV,Mo,CC,ES,SC
Lazuli Bunting *Passerina amoena*	NC,CV,Mo,CC,ES,SC
Yellow-billed Magpie *Pica nuttalli*	CV,CC
Black-billed Magpie *Pica pica*	Mo,ES
Nuttall's Woodpecker *Picoides nuttallii*	NC,CV,Mo,CC,SC
Downy Woodpecker *Picoides pubescens*	NC,CV,Mo,CC,SC
Hairy Woodpecker *Picoides villosus*	NC,CV,CC,ES,SC
Pine Grosbeak *Pinicola enucleator*	CV
Albert's Towhee *Pipilo alberti*	D
California (Brown) Towhee *Pipilo crissalis*	NC,CV,CC,SC
Rufous-sided Towhee *Pipilo erythrophthalmus*	NC,CV,Mo,CC,ES,SC,D
Bushtit *Psaltriparus minimus*	NC,CV,Mo,CC,ES,SC,D
Great-tailed Grackle *Quiscalus mexicanus*	D
Black Phoebe *Sayornis nigricans*	NC,CV,CC,SC,D
Rufous Hummingbird *Selasphorus rufus*	NC
Allen's Humminbird *Selasphorus sasin*	NC,CC,SC
White-breasted Nuthatch *Sitta carolinensis*	NC,CV,Mo,CC,ES,SC
Red-breasted Sapsucker *Sphyrapicus ruber*	NC,CV,Mo,CC,ES,SC
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	NC,CV,Mo,CC,ES,SC,D
Calliope Hummingbird *Stellula calliope*	NC,CV,Mo
Tree Swallow *Tachycineta bicolor*	NC,CV,Mo,CC,ES,SC,D
Bewick's Wren *Thyromanes bewickii*	NC,CV,Mo,CC,ES,SC,D
House Wren *Troglodytes aedon*	NC,CV,Mo,CC,ES,SC,D
American Robin *Turdus migratorius*	NC,CV,Mo,CC,ES,SC,D
Common Barn Owl *Tyto alba*	NC,CV,Mo,CC,ES,SC,D
Warbling Vireo *Vireo gilvus*	NC,CV,Mo,CC,ES,SC
Hutton's Vireo *Vireo huttoni*	NC,CV,CC,ES,SC
Wilson's Warbler *Wilsonia pusilla*	NC,CV,Mo,CC,ES,SC
Mourning Dove *Zenaida macroura*	NC,CV,Mo,CC,ES,SC,D
Golden-crowned Sparrow *Zonotrichia atricapilla*	NC,CV,Mo,CC,ES,SC
White-crowned Sparrow *Zonotrichia leucophrys*	NC,CV,Mo,CC,ES,SC,D

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